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ABSTRACT

This guide is designed to help education and training facilities develop and administer competency-based training programs to qualify and certify trainees in accordance with American Welding Society (AWS) requirements for level III (expert) welders. Presented first are the scope/objectives/requirements of the AWS qualification/certification program. Listed next are the minimum training/qualification requirements expected of expert welders in the following areas: basic skills; work experience; shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); oxyfuel gas cutting, and plasma arc cutting. Section 3 consists of curriculum guidelines for the courses required to meet the minimum training/qualification requirements, a competency-based program outline, and learning modules including the following: learning objective, performance conditions, desired behavior, evaluation criteria, and learning activities. Section 4 consists of general guidelines and performance qualifications for achieving the optional qualification of AWS-certified welder by demonstrating competency in SMAW, GMAW, FCAW, and GTAW. Seven figures are included. Appended are the following: recommendations for support personnel and systems, trainee populations, facility planning, and personal and shop materials/equipment/tools; addresses of major welding fabricating industry associations; sample training achievement record; sample level III welder certificate of completion; and 150 references. (MN)

ED 401 427

Guide for the Training and Qualification of Welding Personnel

Level III – Expert Welder

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Guide for the Training and Qualification of Welding Personnel

Level III – Expert Welders

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Prepared by
AWS Education Department

Under the Direction of
AWS Education Grant Committee

Approved by
AWS Board of Directors

Abstract

This guide contains information to assist education and training facilities in the development and administration of competency-based training that leads to the qualification and certification of trainees in accordance with the requirements of AWS QC12, *Specification for the Qualification and Certification for Level III – Expert Welders*. Included are sections on curriculum and qualification guidelines, as well as recommendations for facility planning, materials, equipment, and tools.

American Welding Society

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This standard is subject to revision at any time by the AWS Education Committee. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are welcomed, and should be addressed to: Director of Education, American Welding Society, 550 N. W. LeJeune Road, Miami, Florida 33126. Such comments will receive careful consideration by the AWS Education Committee, and the author of the comments will be informed of the committee's response to the comments. Guests are invited to attend all meetings of the AWS Education Committee to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these rules can be obtained from the American Welding Society, 550 N. W. LeJeune Road, Miami, Florida 33126.

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A special note of appreciation is extended to each member of the American Welding Society who participated in the second industrial survey that helped identify the skill requirements for the Level III – Expert Welder.

Foreword

(This Foreword is not a part of EG4.0–96, *Guide for the Training and Qualification of Welding Personnel Level III – Expert Welder*, but is included for information purposes only.)

The American Welding Society (AWS), recognizing the need for competent welders, through a grant by the U. S. Department of Education (DOEd), formed the Education Grant Committee and assigned them the task of preparing this guide.

Welding has become a very sophisticated and technical science, requiring not only mental application but also hands-on abilities. The future need for competent welders should prompt the establishment of a greater number of educational programs. Thus, it becomes imperative that the training given be of a quality and quantity that adequately prepares trainees for industrial assignments at various levels of skill development well into the next century. To this end, Level III – Expert Welders come to the workforce possessing a prerequisite amount of knowledge, attitudes, skills and habits required to perform tasks autonomously, including the selection and use of appropriate techniques and equipment, and to apply theoretical knowledge and motor skills with minimum supervision.

As the name implies, it is the intent of this document to serve as a *Guide* for those wishing to establish, expand, or enhance a private or public training program for Level III – Expert Welders. The basic requirements contained in this document are established as a result of individuals from a broad range of businesses, job classifications and industrial or educational areas participating in a national survey to identify welder skills. In conjunction with industry's response and the AWS Education Grant Committee's consensus, this document establishes the minimum requirements necessary to standardize the training and qualification of Level III – Expert Welders throughout the United States of America. Members of the AWS community and the Education Grant Committee have a growing interest in positively promoting welder training and providing minimum standards for it's delivery.

The American Welding Society welcomes comments on this publication, and communications should be addressed to: The American Welding Society, Attention: Director of Education, 550 N. W. LeJeune Road, Miami, Florida, 33126.

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1. General

1.1 Scope. This guide establishes a minimum skill standard defining training and qualification requirements that are necessary for Participating Organizations to develop and administer a Level III – Expert Welder Program in accordance with AWS QC12, *Specification for the Qualification and Certification for Level III – Expert Welders*. This Guide is intended to specify a credible path for post-secondary or employer-based training facilities to build new programs and/or enhance existing programs to administer Level III – Expert Welder training and qualification. Use of this guide is voluntary. Participating Organizations desiring to certify a trainee as an AWS Certified Level III – Expert Welder shall consider the training and qualification guidelines within this document as mandatory requirements under the requirements of AWS QC12. Participating Organizations may elect to supersede written examination and certify welders according to the requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*. Further, Participating Organizations may also elect to use, or become, AWS Accredited Test Facilities under the requirements of AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program* and qualify expert welders according to the requirements of AWS QC7, *Standard for AWS Certified Welders*.

1.2 Objectives

1.2.1 Provide training facilities with an industrial awareness of the occupational description, conditions, task listing, and profile that encompasses the job classification of Level III – Expert Welder.

1.2.2 Establish a broad competency-based curriculum detailing the minimum acceptable skill and work experience requirements for the training and qualification of expert welders.

1.2.3 Provide training facilities participating in the certification of expert welders with a list of learning objectives and learning activities necessary to accomplish Level III – Expert Welder training.

1.2.4 Provide training facilities participating in the certification of expert welders with the references needed to compare existing or new curriculum with the AWS documents specified in this guide.

1.2.5 Provide training facilities participating in the certification of expert welders with information related to the administration of Level III – Expert Welder, written examination and performance qualification testing.

1.2.6 Provide training facilities participating in the certification of expert welders with information related to optional AWS QC12, *Level III – Expert Welder Program* requirements for written examinations administered under AWS QC1, *Standard for AWS Certification of Welding Inspectors*.

1.2.7 Provide training facilities participating in the certification of expert welders with information related to optional AWS QC12, *Level III – Expert Welder Program* requirements for performance qualification tests administered at an AWS QC4, *Accredited Test Facility* through the AWS QC7, *Certified Welder Program*.

1.3 Requirements

1.3.1 Unless the post-secondary or employer-based training facility elects to become a Participating Organization under the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*, use of this document is voluntary.

1.3.2 Participating Organizations shall meet the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*.

1.3.3 Participating Organizations shall ensure that existing or new training materials are in compliance with the AWS documents specified in section 3, *Curriculum Guidelines* of this guide.

1.3.4 Participating Organizations shall administer a written safety examination prior to trainee performance of tasks in the work area or laboratory, in accordance with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*.

1.3.5 Participating Organizations shall administer performance qualification testing at the end of training for each applicable welding process in accordance with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*.

1.3.6 Participating Organizations shall provide a means for trainees to take a three part examination consisting of Part A - Welding Fundamentals and Safety (based on the applicable subject matter identified in section 3, *Curriculum Guidelines* of this guide), Part B - Practical Welding Specification Interpretation (visual examination of weld samples), and Part C - Code Book Interpretation (open book examination based on one of the following: AWS D1.1, API 1104 or ASME Section IX).

1.3.7 Trainees desiring entrance into the AWS Level III – Expert Welder Certification program shall possess the necessary documentation of training, or demonstrate the ability to pass workmanship qualifications, written examination and performance qualifications in accordance with the requirements of AWS QC10, *Specification for Qualification and Certification for Entry Level Welders* and AWS QC11, *Specification for Qualification and Certification for Level II – Advanced Welders*.

1.3.8 Trainees desiring AWS Level III – Expert Welder Certification shall pass a three part examination consisting of Part A - Welding Fundamentals and Safety (based on the applicable subject matter identified in section 3, *Curriculum Guidelines* of this guide), Part B - Practical Welding Specification Interpretation (visual examination of weld samples), and Part C - Code Book Interpretation (open book examination based on one of the following: AWS D1.1, API 1104 or ASME Section IX).

1.3.8.1 Trainees desiring AWS Level III – Expert Welder Certification through training, testing and examination under the requirements of AWS QC12 shall meet the requirements of **1.3.7**, **1.3.8** and document two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

1.3.8.2 Trainees desiring AWS Level III – Expert Welder Certification through testing and examination under the requirements of AWS QC12 shall meet the requirements of **1.3.7**, **1.3.8** and document seven years welding work experience. Said work experience shall consist of three years in a single process and 4 years using multiple processes, (with a minimum of 6 months fabrication

experience that includes drawing interpretation, layout and fitup duties) that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

1.3.8.3 At the discretion of a Participating Organization, credit for completion of individual training requirements and work experience may be simultaneously granted to an AWS QC12 Level III – Expert Welder applicant provided the work experience or experiential learning meets or exceeds the requirements for either work experience or training.

1.3.8.4 Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher,, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination (refer to section 5).

1.3.8.5 Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4.)

1.3.9 Trainees failing the AWS Level III – Expert Welder Certification written examination shall retest on all portions of the exam until competency is achieved in accordance with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*. This requirement however, shall not supersede the authority of the local training evaluation criteria as established in the facility's guidelines.

1.3.10 Trainees desiring AWS Level III – Expert Welder Certification shall pass performance qualification tests in accordance with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*.

1.3.11 Optional written examinations for Level III – Expert Welders shall conform to the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*, for written examinations administered under AWS QC1, *Standard for AWS Certification of Welding Inspectors*. (Refer to section 5 of this guide.)

1.3.11.1 In accordance with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*, all applicants for written examinations administered under AWS QC1, *Standard for AWS Certification of Welding Inspectors* shall be required to take a supplemental written safety examination and pass with 90% accuracy. (Refer to section 5 of this guide.)

1.3.12 Optional welder performance qualification tests for Level III – Expert Welders shall conform to the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*, for welder performance tests administered at an AWS QC4, *Accredited Test Facility* using the AWS QC7, *Certified Welder Program*. (Refer to section 4 of this guide.)

1.3.13 Participating Organizations shall keep training records reflecting the results of Level III – Expert Welder training, written examination, performance qualification, and as applicable optional AWS QC7 welder performance qualification tests or AWS QC1 Certified Welding Inspector examination.

2. Industrial Awareness

2.1 Scope. Training facilities must understand the needs of industry and provide programs that prepare students to fill these needs. To establish a successful program for welder training, the first step would be to understand the job functions of this person in industry. This is difficult because of the highly diverse nature of these functions and the fact that they vary from industry to industry and from company to company. Recognizing this diversity, AWS conducted an industry-wide survey, covering a broad base of businesses, job classifications, and educational institutions, to gather and analyze information pertinent to the skills a Level III – Expert Welder should possess. From a needs assessment and analysis, a profile of the Level III – Expert Welder was developed (refer to Figure 1). The profile identifies skill and knowledge areas common to all expert welders, regardless of their unique situation in industry. To assist institutions in increasing their awareness of industry's needs, the following sections include portions of the occupational data collected during the needs assessment and analysis phase of this project.

2.2 Level III – Expert Welder Definition. An individual employed in this position is considered to possess a prerequisite amount of knowledge, attitude, skills, and habits required to perform tasks autonomously, including the selection and use of appropriate techniques and equipment, and to apply theoretical knowledge and motor skills with minimum supervision.

2.3 Level III – Expert Welder Occupational Description. The position is comprised of the following areas:

2.3.1 Prerequisite Knowledge and Skills. Trainees desiring entrance into the AWS Level III – Expert Welder Certification program shall possess the necessary documentation of training, or demonstrate the ability to pass workmanship qualifications, written examination and performance qualifications in accordance with the requirements of AWS QC10, *Specification for Qualification and Certification for Entry Level Welders* and AWS QC11, *Specification for Qualification and Certification for Level II – Advanced Welders.*

2.3.1.1 Trainees desiring AWS Level III – Expert Welder Certification through training, examination and testing under the requirements of AWS QC12 shall document two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure prior to issuance of Level III – Advanced Welder Certification.

2.3.1.2 Trainees desiring AWS Level III – Expert Welder Certification through examination and testing under the requirements of AWS QC12 shall document seven years welding work experience. Said work experience shall consist of three years in a single process and 4 years using multiple processes (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure prior to issuance of Level III – Advanced Welder Certification.

2.3.1.3 Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination (refer to section 5).

2.3.1.4 Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4)

2.3.2 Supervision and Management. Demonstrates the ability to lead others while performing hands-on tasks during fabrication and welding operations. Is capable of administering hands-on training. Has a basic understanding of training methods, learning and training styles, and assessment of trainee progress. Is knowledgeable about equipment selection and specifications for purchase. Has the ability to estimate welding and material costs and quantities.

2.3.3 Layout/Fitup Practices. Possesses the prerequisite drawing and welding symbol interpretation skills of a Level II – Advanced Welder. Demonstrates the ability to troubleshoot fabrication setups and and processes. Participates in the specification of equipment selection and purchase. Performs a variety of hands-on tasks associated with layout and fitup while supervising others during the fabrication process. Employs first level inspection practices during various stages of fabrication. Fabricates jigs, fixtures and positioners. From complex drawings the Expert Welder sets up, prepares cutting lists and sequences parts for fabrication and assembly of weldments. During assembly the Expert Welder compensates for distortion and shrinkage.

2.3.4 Welding Codes and Other Standards. Possesses the prerequisite knowledge and interpretation skills of welding codes and other standards for a Level II – Advanced Welder. Demonstrates the ability to locate and use welding and inspection requirement information from: Welding Procedure Specifications (WPS's), AWS D1.1, *Structural Welding Code – Steel*, API Standard 1104, *Standard for Welding Pipelines and Related Facilities*, ASME, *Boiler and Pressure Vessel Code – Section IX* and In-House (Employer) Standards.

2.3.5 Welding Inspection and Testing. Possesses the prerequisite knowledge and interpretation skills of welding inspection and testing for a Level II – Advanced Welder. Demonstrates the ability to interpret welding and inspection requirements for various assignments. Interprets welding inspection results from visual examination, penetrant testing and magnetic particle testing. Prepares inspection reports. Has a fundamental understanding of ultrasonic and radiographic testing results. Performs visual examination, bend, penetrant and magnetic particle testing. Demonstrates the ability to take or suggest corrective actions.

2.3.6 Arc Welding. Possesses the prerequisite arc welding skills of a Level II Advanced Welder. Demonstrates the ability to troubleshoot welding setups and and processes. Participates in the specification of equipment selection and purchase. Performs a variety of hands-on tasks while supervising others during welding. Employs first level inspection practices during various stages of welding. Has an understanding of welding metallurgy including; mechanical and chemical properties of metals, weld zone metallurgy, residual stress and control of distortion. Demonstrates knowledge of joint design and preparation, selection of materials, arc welding application, weld quality, weld repairs (corrective actions) and welding inspection. Sets up the components and accessories of a complete welding system. Sets up shielded metal arc welding operations, for all position fillet and groove welding on an unlimited thickness range of carbon steel and stainless steel plate and pipe. Sets up gas metal arc welding (short circuit transfer) operations, for all position fillet and groove welding on an unlimited thickness range of carbon steel plate and pipe. Sets up gas metal arc welding (spray transfer) operations, for a limited position, unlimited thickness range of carbon steel plate and pipe. Sets up gas

metal arc welding (spray transfer and pulsed arc) for all positions fillet and groove welding an unlimited thickness range of aluminum plate and pipe. Sets up flux cored arc welding operations, for all position fillet and groove welding on an unlimited thickness range of carbon steel plate and pipe. Sets up gas tungsten arc welding operations, for all position fillet and groove welding within a limited thickness range of carbon steel, stainless steel and aluminum sheet and tubing. Sets up and performs gas tungsten arc welding operations, for limited position fillet and groove welding within a limited thickness range of nickel, copper, magnesium and/or titanium sheet metals.

2.3.7 Oxyfuel Gas Cutting. Possesses the prerequisite oxyfuel gas cutting skills of a Level II Advanced Welder. Demonstrates the ability to troubleshoot cutting setups and and processes. Participates in the specification of equipment selection and purchase. Performs a variety of hands-on tasks while supervising others during cutting. Employs first level inspection practices during various stages of cutting. Sets up and performs manual oxyfuel gas cutting operations that include straight and shape cutting, beveling, and weld removal (weld washing) for various product forms including plate and pipe. Sets up and operates machine oxyfuel gas cutting equipment (track burner) to perform straight cutting and beveling operations. Demonstrates knowledge of preparation and selection of materials, cutting applications, cut quality and cut surface repairs (corrective actions). Performs minor external repairs to equipment and accessories.

2.3.8 Arc Cutting and Gouging. Possesses the prerequisite arc cutting skills of a Level II Advanced Welder. Demonstrates the ability to troubleshoot cutting setups and and processes. Participates in the specification of equipment selection and purchase. Performs a variety of hands-on tasks while supervising others during cutting. Employs first level inspection practices during various stages of cutting. Sets up and performs manual air carbon arc cutting operations on various product forms including plate and pipe. Sets up and performs manual plasma arc cutting operations on various product forms including plate and pipe. Sets up and operates machine plasma arc cutting equipment (track burner) to perform straight cutting and beveling operations. Demonstrates knowledge of preparation and selection of materials, arc cutting applications, cut quality and cut surface repairs (corrective actions). Performs minor external repairs to equipment and accessories.

2.4 Level III – Expert Welder Occupational Conditions.

2.4.1 Work Environment. Level III – Expert Welders are employed in a wide range of industries that use welding and welding-related tasks during the course of daily operations. This range of industries includes small, medium, and large union or non-union facilities.

2.4.2 Occupational Hazards. As is the case in most metalworking industries, the potential for bodily harm and hazardous situations exists. High electrical currents and voltages are used to operate machinery and welding equipment. Machinery for shearing, forming, and punching various thicknesses of materials is used. Flammable and other compressed gases are used during flame cutting and welding operations. The employee may be in direct contact with heavy sections during lifting and positioning operations. Welders may work in enclosed, restricted spaces, and at times at high elevations and in awkward positions. An undesirable noise level is sometimes generated during the production process. The welder must take safety precautions, and be safety conscious at all times.

2.4.3 Worker Profile. This position involves leadership, concentration, decision making, and physical tasks.

2.4.3.1 Physical Requirements. Level III – Expert Welders must meet the physical requirements established by the employer.

2.4.3.2 Employability. Level III – Expert Welders should exhibit good leadership, written, oral, and listening skills, in addition to competency in problem solving and decision making. These individuals should display good judgement, dependability and interact well with people.

AWS Level III – Expert Welders are capable of performing welding inspection that includes visual examination, bend , penetrant and magnetic particle testing. They are able to interpret test results and prepare inspection reports. These individual may be employed as a working lead- or foreperson and have layout and fitting skills with the ability to work from complex drawings.

AWS Level III – Expert Welders who achieved certification through training, examination and testing possess a minimum of two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure prior to issuance of Level III – Advanced Welder Certification.

AWS Level III – Expert Welders who achieved certification through examination and testing possess a minimum of seven years welding work experience consisting of three years in a single process and 4 years using multiple processes (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure prior to issuance of Level III – Advanced Welder Certification.

AWS Level III – Expert Welders, depending on AWS QC12 written examination options, may enter the workplace as AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI).

AWS Level III – Expert Welders, depending on AWS QC12 performance qualification options, may enter the workplace as AWS QC7 Certified Welders possessing welder certifications to a recognized standard or employer's qualified welding procedure specification.

2.4.3.3 Education. Level III – Expert Welder training may be accomplished through postsecondary, vocational-technical schools, junior colleges, universities, apprenticeship or employer-based welder training programs. Sufficient workplace skills (i.e. foundation skills such as: reading, writing, math, science, communication skills, adaptability skills, employability skills and leadership skills) are required to complete requisite welding related knowledge and skills training.

AWS QC10, Entry Level Welder and AWS QC11, Level II – Advanced Welder skills achieved and substantiated through training/testing or testing alone are a prerequisite to AWS QC12 Level III – Expert Welder training.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination (refer to section 5).

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4)

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

BASIC SKILLS AND KNOWLEDGE

**COMMUNICATION	*ENTRY LEVEL & LEVEL II WELDER REQUIREMENTS PROVIDE DETAILED, SEQUENTIAL DIRECTIONS APPLY CRITICAL THINKING SKILLS TO LOCATE INFORMATION ORGANIZE INFORMATION INTO TASK SEQUENCING WRITE TECHNICAL REPORTS	
**MATHEMATICS	*ENTRY LEVEL & LEVEL II WELDER REQUIREMENTS CALCULATE MATERIAL QUANTITY AND COST FOR FABRICATION CALCULATE BASIC WELDING COSTS	*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM
**LEADERSHIP	PERSONAL LEADERSHIP SKILLS DIAGNOSTIC (PROBLEM SOLVER, CRITICAL AND CREATIVE THINKER) PERCEPTUAL (COMMUNICATES WELL, VERBALLY AND THROUGH LISTENING) BEHAVIORAL (TEAMWORK, NEGOTIATION, INTERPERSONAL DELEGATION, MOTIVATION, COACHING, COUNSELING) ADMINISTER HANDS-ON TRAINING PERFORM DUTIES AS A WORKING FOREMAN OR LEAD PERSON USE INNOVATION TO SOLVE PROBLEMS PERFORM JOB SCHEDULING FUNCTIONS	**RECOMMEND ASSESSMENT AND TESTING PRIOR TO EXITING EXPERT WELDER TRAINING

WORK EXPERIENCE

WITH FORMAL TRAINING	2 YEARS WELDING RELATED WORK EXPERIENCE WITH LEVEL III TRAINING	
NO FORMAL TRAINING	SEVEN YEARS WELDING RELATED WORK EXPERIENCE WITH: 3 YEARS IN A SINGLE PROCESS 4 YEARS IN MULTI-PROCESSES ABILITY TO TEST OUT OF LEVEL I, II AND III WELDER CERTIFICATION	COMPLETION OF LEVEL I & II CERTIFICATION REQUIREMENTS
FABRICATION	A MINIMUM OF 6 MONTHS FABRICATION RELATED WORK EXPERIENCE INCLUDING DRAWING INTERPRETATION, LAYOUT AND FITUP DUTIES SHALL BE INCLUDED IN THE ABOVE WORK EXPERIENCE REQUIREMENTS	WORK EXPERIENCE MUST BE DOCUMENTED PRIOR TO APPLYING FOR LEVEL III CERTIFICATION

Figure 1 – Level III – Expert Welder Profile. This information was developed as a result of a needs assessment and analysis from a national survey distributed to a mailing list obtained from the roles of AWS membership.

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

RELATED SKILLS AND KNOWLEDGE

SAFE PRACTICES	GENERAL SAFETY PROTECTION OF PERSONNEL PROTECTION OF THE WORK AREA VENTILATION FIRE PREVENTION AND PROTECTION CONFINED SPACES PRECAUTIONARY LABELING	MANDATORY SAFETY PRETEST AND MANDATORY SAFETY POST-TEST
*ELECTRICAL FUNDAMENTALS	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS USE ELECTRICAL MEASUREMENT TOOLS PERFORM SIMPLE ELECTRICAL TROUBLESHOOTING	
*DRAWING/WELDING SYMBOL INTERPRETATION	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS **RECOGNIZE AND INTERPRET NDE SYMBOLS **RECOGNIZE AND INTERPRET PIPING SYMBOLS **INTERPRET WELDING SYMBOL INFORMATION FROM COMPLEX DRAWINGS **KNOWLEDGE AND SELECTION OF JOINT DESIGN SUPERVISE OTHERS IN FABRICATION FROM DRAWINGS	*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM
***LAYOUT & FITUP	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS TROUBLESHOOT SETUPS AND PROCESSES PARTICIPATE IN THE SPECIFICATION OF EQUIPMENT PURCHASES FABRICATION OF JIGS AND FIXTURES PREPARATION OF CUTTING LISTS SEQUENCING OF PARTS FOR FABRICATION COMPENSATE FOR DISTORTION AND SHRINKAGE FABRICATE WELDMENTS FROM COMPLEX DRAWINGS	**PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION
WELDING CODES & OTHER STANDARDS	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS **INTERPRET WELDING AND INSPECTION REQUIREMENTS FROM: WELDING PROCEDURE SPECIFICATION INFORMATION AWS D1.1 CODE INFORMATION API 1104 CODE INFORMATION ASME, SEC IX CODE INFORMATION IN-HOUSE STANDARDS	***LAYOUT AND FITUP TRAINING MAY BE SUBSTITUTED WITH 6 MONTHS DOCUMENTED EMPLOYMENT IN RELATED SUBJECTS OR THROUGH CO-OPERATIVE WORK AGREEMENTS (SCHOOL-TO-WORK)
WELDING INSPECTION AND TESTING	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS INTERPRETATION OF WELDING INSPECTION RESULTS FROM: VISUAL EXAMINATION PENETRANT TESTING MAGNETIC PARTICLE TESTING FUNDAMENTAL UNDERSTANDING OF ULTRASONIC TESTING RESULTS FUNDAMENTAL UNDERSTANDING OF RADIOGRAPHIC TESTING RESULTS PREPARE WELDING INSPECTION REPORTS *PERFORM VISUAL EXAMINATION PERFORM PENETRANT TESTING PERFORM MAGNETIC PARTICLE TESTING ABILITY TO TAKE OR SUGGEST CORRECTIVE ACTIONS	OPTIONAL EXAMINATION AWS QC1 - CWI PROGRAM CERTIFIED WELDING INSPECTOR

Figure 1 – Level III – Expert Welder Profile (continued).

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LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

ARC WELDING PROCESSES and RELATED KNOWLEDGE

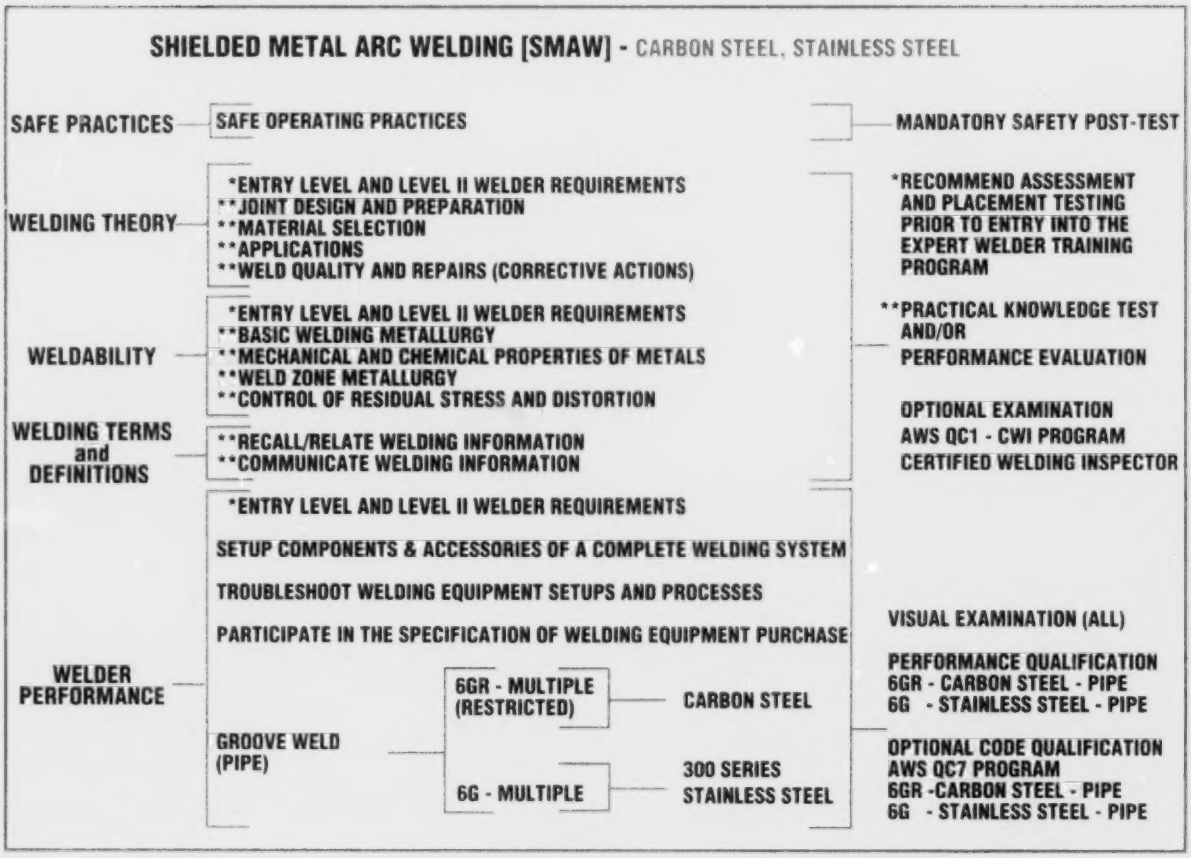
SHIELDED METAL ARC WELDING [SMAW] - CARBON STEEL, STAINLESS STEEL
SAFE PRACTICES
SAFE OPERATING PRACTICES
MANDATORY SAFETY POST-TEST
WELDING THEORY
*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
**JOINT DESIGN AND PREPARATION
**MATERIAL SELECTION
**APPLICATIONS
**WELD QUALITY AND REPAIRS (CORRECTIVE ACTIONS)
*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM
WELDABILITY
*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
**BASIC WELDING METALLURGY
**MECHANICAL AND CHEMICAL PROPERTIES OF METALS
**WELD ZONE METALLURGY
**CONTROL OF RESIDUAL STRESS AND DISTORTION
**PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION
WELDING TERMS and DEFINITIONS
**RECALL/RELATE WELDING INFORMATION
**COMMUNICATE WELDING INFORMATION
OPTIONAL EXAMINATION
AWS QC1 - CWI PROGRAM
CERTIFIED WELDING INSPECTOR
WELDER PERFORMANCE
*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
SETUP COMPONENTS & ACCESSORIES OF A COMPLETE WELDING SYSTEM
TROUBLESHOOT WELDING EQUIPMENT SETUPS AND PROCESSES
PARTICIPATE IN THE SPECIFICATION OF WELDING EQUIPMENT PURCHASE
VISUAL EXAMINATION (ALL)
PERFORMANCE QUALIFICATION
6GR - CARBON STEEL - PIPE
6G - STAINLESS STEEL - PIPE
GROOVE WELD (PIPE)
6GR - MULTIPLE (RESTRICTED)
CARBON STEEL
6G - MULTIPLE
300 SERIES STAINLESS STEEL
OPTIONAL CODE QUALIFICATION
AWS QC7 PROGRAM
6GR -CARBON STEEL - PIPE
6G - STAINLESS STEEL - PIPE

Figure 1 – Level III – Expert Welder Profile (continued).

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

ARC WELDING PROCESSES and RELATED KNOWLEDGE (CONTINUED)

GAS METAL ARC WELDING [GMAW-S, GMAW-P] - CARBON STEEL, ALUMINUM

SAFE PRACTICES
- SAFE OPERATING PRACTICES
- MANDATORY SAFETY POST-TEST

WELDING THEORY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **JOINT DESIGN AND PREPARATION
- **MATERIAL SELECTION
- **APPLICATIONS
- **WELD QUALITY AND REPAIRS (CORRECTIVE ACTIONS)

*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM

WELDABILITY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **BASIC WELDING METALLURGY
- **MECHANICAL AND CHEMICAL PROPERTIES OF METALS
- **WELD ZONE METALLURGY
- **CONTROL OF RESIDUAL STRESS AND DISTORTION

**PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION

WELDING TERMS and DEFINITIONS
- **RECALL/RELATE WELDING INFORMATION
- **COMMUNICATE WELDING INFORMATION

OPTIONAL EXAMINATION
AWS QC1 - CWI PROGRAM
CERTIFIED WELDING INSPECTOR

WELDER PERFORMANCE
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- SETUP COMPONENTS & ACCESSORIES OF A COMPLETE WELDING SYSTEM
- TROUBLESHOOT WELDING EQUIPMENT SETUPS AND PROCESSES
- PARTICIPATE IN THE SPECIFICATION OF WELDING EQUIPMENT PURCHASE

VISUAL EXAMINATION (ALL)

PERFORMANCE QUALIFICATION
6G - CARBON STEEL - PIPE
6G - ALUMINUM - PIPE

GMAW-S (Short Circuiting)
- GROOVE WELD (PIPE) — 6G - MULTIPLE — CARBON STEEL

GMAW-P (Pulsed)
- GROOVE WELD (PIPE) — 6G - MULTIPLE — ALUMINUM

OPTIONAL CODE QUALIFICATION
AWS QC7 PROGRAM
6G - CARBON STEEL - PIPE
6G - ALUMINUM - PIPE

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Figure 1 – Level III – Expert Welder Profile (continued).

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

ARC WELDING PROCESSES and RELATED KNOWLEDGE (CONTINUED)

FLUX CORED ARC WELDING [FCAW-S, FCAW-G] - CARBON STEEL

SAFE PRACTICES	SAFE OPERATING PRACTICES	MANDATORY SAFETY POST-TEST
WELDING THEORY	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS **JOINT DESIGN AND PREPARATION **MATERIAL SELECTION **APPLICATIONS **WELD QUALITY AND REPAIRS (CORRECTIVE ACTIONS)	*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM
WELDABILITY	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS **BASIC WELDING METALLURGY **MECHANICAL AND CHEMICAL PROPERTIES OF METALS **WELD ZONE METALLURGY **CONTROL OF RESIDUAL STRESS AND DISTORTION	**PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION
WELDING TERMS and DEFINITIONS	**RECALL/RELATE WELDING INFORMATION **COMMUNICATE WELDING INFORMATION	OPTIONAL EXAMINATION AWS QC1 - CWI PROGRAM CERTIFIED WELDING INSPECTOR
WELDER PERFORMANCE FCAW-S (Self-Shielded) FCAW-G (Gas-Shielded)	*ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS SETUP COMPONENTS & ACCESSORIES OF A COMPLETE WELDING SYSTEM TROUBLESHOOT WELDING EQUIPMENT SETUPS AND PROCESSES PARTICIPATE IN THE SPECIFICATION OF WELDING EQUIPMENT PURCHASE GROOVE WELD (PIPE) — 6G - MULTIPLE — CARBON STEEL	VISUAL EXAMINATION (ALL) PERFORMANCE QUALIFICATION 6G - CARBON STEEL - PIPE OPTIONAL CODE QUALIFICATION AWS QC7 PROGRAM 6G - CARBON STEEL - PIPE

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Figure 1 – Level III – Expert Welder Profile (continued).

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

ARC WELDING PROCESSES and RELATED KNOWLEDGE (CONTINUED)

GAS TUNGSTEN ARC WELDING [GTAW] - CARBON STEEL, STAINLESS STEEL, ALUMINUM, NICKEL, COPPER, MAGNESIUM AND TITANIUM ALLOYS

SAFE PRACTICES
- SAFE OPERATING PRACTICES
- MANDATORY SAFETY POST-TEST

WELDING THEORY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **JOINT DESIGN AND PREPARATION
- **MATERIAL SELECTION
- **APPLICATIONS
- **WELD QUALITY AND REPAIRS (CORRECTIVE ACTIONS)

*RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE EXPERT WELDER TRAINING PROGRAM

WELDABILITY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **BASIC WELDING METALLURGY
- **MECHANICAL AND CHEMICAL PROPERTIES OF METALS
- **WELD ZONE METALLURGY
- **CONTROL OF RESIDUAL STRESS AND DISTORTION

**PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION

WELDING TERMS and DEFINITIONS
- **RECALL/RELATE WELDING INFORMATION
- **COMMUNICATE WELDING INFORMATION

OPTIONAL EXAMINATION
AWS QC1 - CWI PROGRAM
CERTIFIED WELDING INSPECTOR

WELDER PERFORMANCE GTAW
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- SETUP COMPONENTS & ACCESSORIES OF A COMPLETE WELDING SYSTEM
- TROUBLESHOOT WELDING EQUIPMENT SETUPS AND PROCESSES
- PARTICIPATE IN THE SPECIFICATION OF WELDING EQUIPMENT PURCHASE

VISUAL EXAMINATION (ALL)

PERFORMANCE QUALIFICATION
ROUND TUBING or PIPE
6G - CARBON STEEL
6G - STAINLESS STEEL
6G - ALUMINUM

GROOVE AND FILLET WELD (SHEET) — 1G - FLAT, 2F - HORIZONTAL — NICKEL, COPPER, MAGNESIUM, TITANIUM

OPTIONAL CODE QUALIFICATION
AWS QC7 PROGRAM
ROUND TUBING or PIPE
6G - CARBON STEEL
6G - STAINLESS STEEL
6G - ALUMINUM

GROOVE WELD (ROUND TUBING) — 6G - MULTIPLE — CARBON STEEL, 300 SERIES STAINLESS STEEL, ALUMINUM

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Figure 1 – Level III – Expert Welder Profile (continued).

LEVEL III - EXPERT WELDER PROFILE

[Minimum Training and Qualification Requirements]

OXYFUEL GAS AND ARC CUTTING PROCESSES and RELATED KNOWLEDGE

OXYFUEL GAS CUTTING [OFC] - CARBON STEEL

SAFE PRACTICES
- SAFE OPERATING PRACTICES
- HANDLING AND STORAGE OF COMPRESSED GASES

→ MANDATORY SAFETY POST-TEST

CUTTING THEORY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **MATERIAL SELECTION
- **APPLICATIONS
- **CUTTING QUALITY AND REPAIRS (CORRECTIVE ACTIONS)

CUTTING TERMS and DEFINITIONS
- **RECALL/RELATE CUTTING INFORMATION
- **COMMUNICATE CITTING INFORMATION

→ *RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE ADVANCED WELDER TRAINING PROGRAM

→ **PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION

→ OPTIONAL EXAMINATION AWS QC1 - CWI PROGRAM CERTIFIED WELDING INSPECTOR

WELDER PERFORMANCE (MANUAL AND MACHINE) [TRACK BURNER] [PIPE CUTTING EQUIPMENT]
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- SETUP COMPONENTS & ACCESSORIES OF A COMPLETE CUTTING SYSTEM
- TROUBLESHOOT CUTTING EQUIPMENT SETUPS AND PROCESSES
- PARTICIPATE IN THE SPECIFICATION OF CUTTING EQUIPMENT PURCHASE
- STRAIGHT CUTTING
- BEVELING
- SHAPE CUTTING

→ PLATE and PIPE

→ VISUAL EXAMINATION

→ PERFORMANCE EVALUATION

PLASMA ARC CUTTING [PAC] - CARBON STEEL, STAINLESS STEEL, ALUMINUM, NICKEL, COPPER, MAGNESIUM AND TITANIUM ALLOYS

SAFE PRACTICES
- SAFE OPERATING PRACTICES
- HANDLING AND STORAGE OF COMPRESSED GASES

→ MANDATORY SAFETY POST-TEST

CUTTING THEORY
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- **MATERIAL SELECTION
- **APPLICATIONS
- **CUTTING QUALITY AND REPAIRS (CORRECTIVE ACTIONS)

CUTTING TERMS and DEFINITIONS
- **RECALL/RELATE CUTTING INFORMATION
- **COMMUNICATE CITTING INFORMATION

→ *RECOMMEND ASSESSMENT AND PLACEMENT TESTING PRIOR TO ENTRY INTO THE ADVANCED WELDER TRAINING PROGRAM

→ **PRACTICAL KNOWLEDGE TEST AND/OR PERFORMANCE EVALUATION

→ OPTIONAL EXAMINATION AWS QC1 - CWI PROGRAM CERTIFIED WELDING INSPECTOR

WELDER PERFORMANCE (MANUAL)
- *ENTRY LEVEL AND LEVEL II WELDER REQUIREMENTS
- SETUP COMPONENTS & ACCESSORIES OF A COMPLETE CUTTING SYSTEM
- TROUBLESHOOT CUTTING EQUIPMENT SETUPS AND PROCESSES
- PARTICIPATE IN THE SPECIFICATION OF CUTTING EQUIPMENT PURCHASE
- STRAIGHT CUTTING
- BEVELING
- SHAPE CUTTING

→ PLATE and PIPE

→ VISUAL EXAMINATION

→ PERFORMANCE EVALUATION

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3. Curriculum Guidelines

3.1 General Guidelines. It is the sole intent of this document to define a competency-based welding curriculum. The course structure of this curriculum is not sequenced for linear delivery (i.e. from course A to B, etc.). Therefore, it is the responsibility of the post-secondary or employer-based training program to establish any guidelines for the duration of training, prerequisites related to basic skills and sequencing of instructional activities. Training activities should consistently reinforce the use of basic skills (i.e. reading, writing, math and communications) and previously acquired Entry Level and Level II Welder skills.

3.1.1 Preassessment. The welding industry wants expert welders with strong reading, writing, mathematics, listening and oral communication, employability and leadership skills that are closely related to job performance. The curriculum in this guide also requires sufficient basic skills to carry out and complete the training. Therefore, it is strongly recommended that prospective trainees undergo a preplacement assessment for basic skill competency prior to entry into the welding program. Further, the competency level for said skills should meet the Grade Level Content or GED Level for the applicable welder level, as defined by federal or state guidelines.

3.1.2 Curriculum Conventions. Terminology associated with the curriculum Guidelines is defined as follows:

Competency-Based Program Outline: The outline converts the *primary occupation* (i.e. Level III – Expert Welder), *occupational specialties* (e.g. arc welding), *sub-specialties* (e.g. shielded metal arc welding) and *tasks* (e.g. Perform Safety Inspections of Equipment and Accessories) to a *program title* (i.e. Level III – Expert Welder Training), *courses* (e.g. Course B: Arc Welding Principles and Practices), *units* (e.g. Unit #1: Shielded Metal Arc Welding) and *learning objectives* (e.g. Learning Objective #1: Perform safety inspection of equipment and accessories.) The outline assists in modularizing the training program.

Learning Objectives: A written statement cast in the future which defines the *conditions* under which learning will occur and the *criteria* for determining when the objective has been attained. The following elements comprise a learning objective:

Title: A phrase that specifies the activity. The title of a learning objective is the same as the title of the task from which it was derived.

Performance Conditions: A statement which defines the "givens" under which the trainee will perform the objective. In most instances, the conditions define the teaching methods, the equipment, tools materials and supplies given the trainee, and the learning environment where training takes place.

Desired Behavior: A statement, written in the future tense, specifying the activity to be performed.

Evaluation Criteria: A statement which establishes the standard against which the trainee's performance of the objective is measured. The basic elements of evaluation may contain a product statement (when the objective has been performed correctly), and if appropriate, a process statement, inspection, time limitations or repetitions of the objective performed by the trainee over a given period of time.

Learning Modules: A learning module establishes the basis for individualizing the learning objective of the training program. These modules identify and organize learning activities for a learning objective.

Learning Activities: An organizational concept that sequences training events in a systematic approach for guiding trainees to a defined objective. Learning activities consist of *knowledge-related* activities and *performance-related activities*. Knowledge-related learning activities are divided into two types: *knowledge acquisition* – sources of information which provide the knowledge needed to perform the learning activity; and *information review* and *testing* (formative testing) activities which guide the instructor in reviewing and assessing the trainee's performance of the learning objective. Knowledge-related learning activities are brought to a close with the trainee's successful completion of a related information test (formative testing). Performance-related learning activities provide the instructor with a means by which to guide the trainee in attaining the objective. Utilizing the now–acquired technical information to guide his or her actions, the trainee receives a *demonstration* of the objective, *practices* performing it until an acceptable level of skill and confidence is gained, and takes a *performance test* (i.e. performance qualifications and written examination) of the same to confirm mastery of the objective. Other performance-related activities may be included in the basic sequence, but the demonstration–practice–performance trilogy is fundamental to ordering performance-related activities.

Closed Book Examination: A practical knowledge test for safety and welding related knowledge. This examination will measure the trainee's knowledge, comprehension and application of major subject matter concepts from classroom instruction. This three part *summative test* is administered at the end of the training cycle.

Participating Organizations may elect to substitute AWS QC12 written examination requirements by providing a means for trainees to register and take a written examination through the AWS QC1, *Certified Welding Inspector Program*, and have expert welders certify according to the requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*. and section 4, *Optional Welder Qualification – AWS QC7 – Certified Welders* of this guide.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination (refer to section 5).

Performance Qualification: A practical application test of manipulative skills using all arc welding processes required by AWS QC12, *Specification for the Qualification and Certification for Level III – Expert Welders*. Performance is measured using visual examination and bend test or radiographic criteria. This *summative test* is conducted at the end of the training for each applicable welding process.

Participating Organizations may elect to use, or become, AWS Accredited Test Facilities under the requirements of AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program* and administer performance qualifications, then certify expert welders according to the requirements of AWS QC7, *Standard for AWS Certified Welders* and section 4. *Optional Welder Qualification – AWS QC7 – Certified Welders* of this guide.

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4)

Work Experience: An individual's work related experience shall be completed prior to issuance of AWS QC12 Level III – Expert Welder Certification. Trainees desiring AWS Level III – Expert Welder Certification through training, examination and testing under the requirements of AWS QC12 shall document two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure. Trainees desiring AWS Level III – Expert Welder Certification through testing and examination under the requirements of AWS QC12 shall document seven years welding work experience. Said work

experience shall consist of three years in a single process and 4 years using multiple processes that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written (refer to section 5).

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4.)

3.1.3 Curriculum Implementation.

3.1.3.1 Review. Participating Organizations shall review part **3.2 Competency-Based Program Outline** (all inclusive) and **3.3 Learning Modules** (all inclusive), prior to the introduction of the curriculum into the training cycle.

Note: The Competency-Based Program Outline should not be construed as the steps necessary to administer the curriculum. It, as the title implies, is an outline that may be used to quickly identify a point in training. The Learning Modules are the heart of the curriculum and contain sufficient information for instructors to deliver the training and evaluate a trainee's performance. Learning Modules include course title, learning objectives, performance conditions, desired behavior, evaluation criteria and learning activities.

3.1.3.2 Verification. Participating Organizations shall ensure that their existing or newly developed curriculum is in compliance with all AWS documents specified in part **3.3 Learning Modules**. Verification shall be made in writing in accordance with AWS QC12, *Specification for the Qualification and Certification for Level III – Expert Welders.*

3.1.3.3 Lesson Plan Development. Participating Organizations shall develop appropriate lesson plans that include each learning objective and the learning activities specified for each course or unit within a course. (Refer to 3.3 Learning Modules.)

Note: Not all learning objectives are stand alone in terms of instruction. Some are delivered through a minimum period of instruction and reinforced throughout the training cycle. Determination of stand alone or continuous reinforcement is identified in the evaluation criteria for each learning objective.

3.1.3.4 Delivery. It is the sole responsibility of a Participating Organization to determine sequencing of instruction. However, Participating Organizations shall deliver training in accordance with the learning objectives and learning activities detailed in **3.3 Learning Modules**.

3.1.3.5 Testing and Examination. Participating Organizations shall develop and administer appropriate formative tests during and after the completion of classroom instruction. Summative testing for performance qualification, (see Figures 2 through 6), should be administered at the end of training in each applicable welding process. Summative testing for safety and practical welding knowledge shall be administered at the end of the training cycle in accordance with the requirements of AWS QC12, *Specification for the Qualification and Certification for Level III – Expert Welders.*

Participating organizations electing to use the QC7 or AWS QC1 options of AWS QC12 may substitute the written examination or any performance qualification test detailed in **3.3 Learning Modules** for the applicable welder performance qualification test detailed in sections **4, Optional Welder Qualification – AWS QC7 – Certified Welders** and **5, Optional Written Examinations – AWS QC1 – Certified Welding Inspectors**. When the optional AWS QC1 written examination or any AWS QC7

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performance qualification test is substituted, it shall not be necessary to duplicate the AWS QC12 written examination or applicable performance qualification test found in **3.3 Learning Modules** of this guide.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination (refer to section 5).

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program. (refer to section 4.)

Note: In accordance with the requirements of AWS QC12, Specification for Qualification and Certification for Level III – Expert Welders, all applicants for written examinations administered under AWS QC1, Standard for AWS Certification of Welding Inspectors shall be required to take a supplemental written safety examination and pass with 90% accuracy. (Refer to section 4 of this guide.)

3.1.3.6 Work Experience and/or Experiential Learning. Participating Organizations may at their discretion grant credit for both training and work experience simultaneously when either or both work experience and experiential learning are part of the institutions curriculum, provided the work or experiential learning meet or exceed the extent of training or work experience required in accordance with AWS QC12, Expert Welder Program.

3.1.3.7 Record Keeping. Participating Organizations shall develop appropriate records that track each trainee's achievements. In addition, appropriate records shall be developed so that trainees may keep a self-record of achievement. See Annex E.

3.1.3.8 Documentation, Certification and Registry. Participating Organizations desiring AWS QC12 Level III – Expert Welder certification for trainees shall comply with the requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*, sections **7. Documentation**, **8, Certification** and **9, National Registry of Level III – Expert Welders**.

Trainees desiring AWS Level III – Expert Welder Certification through training, examination and testing under the requirements of AWS QC12 shall document two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

Trainees desiring AWS Level III – Expert Welder Certification through testing and examination under the requirements of AWS QC12 shall document seven years welding work experience. Said work experience shall consist of three years in a single process and 4 years using multiple processes (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination and **5, Optional Written Examination – AWS QC1 – Certified Welding Inspectors** of this guide.

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 – Expert Welder Program and **4, Optional Welder Qualification – AWS QC7 – Certified Welders** of this guide.

3.2 Competency Based Program Outline

3.2.1 **Program:** Level III – EXPERT WELDER TRAINING

3.2.1.1 **COURSE A:** WELDING SAFETY and HEALTH

Unit : (no units this course)
Learning Objectives
(1) Follow safe practices.
(2) Recognize the effects of welding on health.

3.2.1.2 **COURSE B:** SUPERVISION and MANAGEMENT

Unit : (no units this course)
Learning Objectives
(1) Supervise other personnel during fabrication and welding operations.
(2) Administer hands-on training.
(3) Participate in the selection and specification of equipment purchases.
(4) Estimate welding and material costs and quantities.

3.2.1.3 **COURSE C:** DOCUMENTS GOVERNING WELDING AND WELDING INSPECTION

Unit 1: WELDING CODES and OTHER STANDARDS
Learning Objectives
(1) Locate essential welding and inspection information from Welding Procedure Specifications (WPS's).
(2) Locate essential welding and inspection information from AWS D1.1, *Structural Welding Code – Steel.*
(3) Locate essential welding and inspection information from API Standard 1104, *Standard for Welding Pipelines and Related Facilities.*
(4) Locate essential welding and inspection information from ASME, *Boiler and Pressure Vessel Code – Section IX.*

Unit 2: WELDING INSPECTION
Learning Objectives
(1) Interpret destructive and nondestructive test results.
(2) Prepare inspection reports.
(3) Perform visual examination.
(4) Perform bend testing.
(5) Perform penetrant testing.
(6) Perform magnetic particle testing.

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3.2.1.4 COURSE D: WELDED METAL FABRICATION

Unit : (no units this course)
Learning Objectives
(1) Troubleshoot fabrication setups and processes.
(2) Interpret welding, nondestructive examination and piping symbols.
(3) Layout parts using advanced measurement practices.
(4) Fabricate weldments from complex drawings.
(5) Fabricate jigs and fixtures.

3.2.1.5 COURSE E: WELDING METALLURGY

Unit:(no units this course)
Learning Objectives
(1) Apply principles of welding metallurgy to welding, fabrication and inspection.
(2) Apply principles of metal properties to welding, fabrication and inspection.
(3) Apply principles related to residual stress and distortion to welding, fabrication and inspection.
(4) Apply principles related to alloy weldability to welding, fabrication and inspection.

3.2.1.6 COURSE F: ARC WELDING PRINCIPLES and PRACTICES

Unit 1: WELDING THEORY
Learning Objectives
(1) Apply principles of joint design and preparation to welding, fabrication and inspection.
(2) Apply principles of material selection to welding, fabrication and inspection.
(3) Apply principles of welding applications to welding, fabrication and inspection.
(4) Apply principles of weld quality and repairs to welding, fabrication and inspection.

Unit 2: SHIELDED METAL ARC WELDING (SMAW)
Learning Objectives
(1) Perform safety inspections of equipment and accessories.
(2) Make minor external repairs to equipment and accessories.
(3) Set up components and accessories of a complete shielded metal arc welding system.
(4) Set up for shielded metal arc welding operations.
(5) Operate shielded metal arc welding equipment.
(6) Execute corrective actions to repair surface flaws on welds and base metals.
(7) Perform a 6GR unlimited thickness range performance qualification test on carbon steel pipe.
(8) Perform a 6G limited thickness range performance qualification test on carbon steel or 300 series stainless steel pipe using stainless steel electrodes.

Unit 3: GAS METAL ARC WELDING (GMAW, GMAW–S)

Learning Objectives

(1) Perform safety inspections of equipment and accessories.
(2) Make minor external repairs to equipment and accessories.
(3) Set up components and accessories of a complete gas metal arc welding system.
(4) Set up for gas metal arc welding operations.
(5) Operate gas metal arc welding equipment.
(6) Execute corrective actions to repair surface flaws on welds and base metals.

Short circuit transfer

(7) Perform a 6G limited thickness range performance qualification test on carbon steel pipe.

Pulsed spray transfer

(8) Perform a 6G limited thickness range performance qualification test on aluminum pipe.

Unit 4: FLUX CORED ARC WELDING (FCAW–S, FCAW–G)

Learning Objectives

(1) Perform safety inspections of equipment and accessories.
(2) Make minor external repairs to equipment and accessories.
(3) Set up components and accessories of a complete flux cored arc welding system.
(4) Set up for flux cored arc welding operations.
(5) Operate flux cored arc welding equipment.
(6) Execute corrective actions to repair surface flaws on welds and base metals.

Self-Shielded

(7) Perform a 6G unlimited thickness range performance qualification test on carbon steel pipe.

Gas-Shielded

(8) Perform a 6G unlimited thickness range performance qualification test on carbon steel pipe.

Unit 5: GAS TUNGSTEN ARC WELDING (GTAW)

Learning Objectives

(1) Perform safety inspections of equipment and accessories.
(2) Make minor external repairs to equipment and accessories.
(3) Set up components and accessories of a complete gas tungsten arc welding system.
(4) Set up for gas tungsten arc welding operations.
(5) Operate gas tungsten arc welding equipment.
(6) Execute corrective actions to repair surface flaws on welds and base metals.
(7) Make 2F and 1G fillet and groove welds, on nickel alloys.
(8) Make 2F and 1G fillet and groove welds, on copper alloys.
(9) Make 2F and 1G fillet and groove welds, on magnesium and/or titanium alloys.
(10) Perform a 6G limited thickness range performance qualification test on carbon steel round tubing or pipe.
(11) Perform two 6G limited thickness range performance qualification tests on carbon steel or stainless steel round tubing or pipe using stainless steel filler metals.
(12) Perform a 6G limited thickness range performance qualification test on aluminum round tubing or pipe.

3.3 LEARNING MODULES

3.3.1 COURSE A: WELDING SAFETY AND HEALTH

LEARNING OBJECTIVE #1: Follow Safe Practices.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, orientation and demonstration about general welding safety, and given the necessary personal protective clothing and equipment, in the work area.

DESIRED BEHAVIOR: the trainee demonstrates safe practices.

EVALUATION CRITERIA: With regard to the trainee, proper protective clothing and equipment are worn, a safe work area is maintained and hazard warnings are communicated to other personnel in the immediate vicinity. The trainee performs the task on a continuous basis over the length of the program, in accordance with the institution's safety policy. Prior to any performance related activity in the institution's work area, the trainee shall pass with 100% accuracy, a written safety examination related to applicable sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*, and the participating organization's internal safety policy. The trainee may retest until 100% accuracy is achieved. In accordance with the requirements of AWS QC12, the trainee shall pass the safety post-test portion of Part A - Welding Fundamentals and Safety (closed book written examination) [summative testing] with 90% accuracy.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide a safety tour and orientation in the institution's welding work area.
3. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, 4. Protection of Personnel and the General Area.
4. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, 5. Ventilation.
5. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, 6. Fire Prevention and Protection.
6. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, 9. Precautionary Information.
7. Provide instruction related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part I – General Aspects.
8. Administer safety examination prior to trainee performance in the institution's work area.
9. Administer safety examination retests as applicable.
10. Prepare trainee for the safety post-test portion of Part A - Welding Fundamentals and Safety (closed book written examination) [summative testing].
11. Keep training records reflecting results of safe practices training.

***Note:** **Where the AWS QC1, Certified Welder Examination option is used to supercede AWS QC12 requirements for written examination, the test applicant shall be required to take a supplemental safety examination in addition to the AWS QC1 examination (see section 5).**

LEARNING OBJECTIVE #2: Recognize the effects of welding on health.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and appropriate welding health training materials, in the classroom or work area,

DESIRED BEHAVIOR: the trainee understands the effects of welding on health.

EVALUATION CRITERIA: The trainee understands welding health issues and applies precautionary measures to protect one's self and other welding personnel from hazardous health situations. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS and other source documents specified for this learning objective.
2. Provide instruction related to the effects of welding on health from AWS EWH, *Effects of Welding on Health I - IX*.
3. Provide instruction related to the effects of welding and cutting fumes and gases from AWS FGW, *Fumes and Gases in the Welding Environment*, Part II, *Arc Welding Fumes and Gases*, Introduction, Equipment, Materials, Procedure and Discussion.
4. Provide instruction related to the effects of welding and cutting fumes and gases from AWS FGW, *Fumes and Gases in the Welding Environment*, Part III, *Brazing Fumes and Gases*, Introduction, Equipment, Materials, Procedure and Discussion.
5. Provide instruction related to the effects of welding and cutting fumes and gases from AWS FGW, *Fumes and Gases in the Welding Environment*, Part IV, *Thermal Spray Fumes and Gases*, Introduction, Equipment, Materials, Procedure and Discussion.
6. Provide instruction related to the effects of welding and cutting fumes and gases from AWS FGW, *Fumes and Gases in the Welding Environment*, Part V, *Fumes and Gases from Oxygen Cutting*, Introduction, Equipment, Materials, Procedure and Discussion.
7. Provide instruction related to welding fume control from ANSI/AWS F3.1, *Guide for Welding Fume Control*, 2. Welding Fume Hazards, 3. General and Dilution Ventilation, 4. Local Exhaust Ventilation Control, 6. Local Exhaust Ventilation Equipment.
8. Provide instruction related to product safety signs and labels from ANSI Z535.4, *Standard for Product Safety Signs and Labels*.
9. Provide instruction related to eye and face protection from ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*.
10. Provide instruction related to respiratory protection from ANSI Z88.2, *Practices for Respiratory Protection*.
11. Provide instruction related to headgear from ANSI Z89.1, *Protective Headware for Industrial Workers*.
12. Develop and administer formative, diagnostic and summative tests relevant to the effects of welding on health.
13. Keep training records reflecting results of the effects of welding on health training.

3.3.1 COURSE B: MANAGEMENT AND SUPERVISION

LEARNING OBJECTIVE #1: Supervise other personnel during fabrication and welding operations.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and experiential learning about supervision and management practices, a fabrication or welding assignment, in the work area,

DESIRED BEHAVIOR: the trainee demonstrates the ability to lead others while performing hands-on tasks.

EVALUATION CRITERIA: The fabrication or welding assignment is completed according to drawing or specification information. During the course of operations the trainee demonstrates the ability to plan, organize and delegate responsibility to others in the accomplishment of various fabrication and welding assignments. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to industrial psychology issues related to a broad understanding of human development and human actions and reactions in the work environment.
3. Provide instruction in basic management related to the five basic principles of management and how it relates to the welding industry.
4. Develop and administer formative, diagnostic and summative tests relevant welding industry supervision.
5. Keep training records reflecting results of welding industry supervision training.

The training facility should:

1. Provide trainee with experiential learning related to supervisor training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **Elements of experiential learning for supervisory training should include:**
Time spent in; Welding Specialties, Production Areas (hands-on area), Inspection Areas (quality assurance)
Interpretation of welding procedures and required codes
Work with a proven, experienced supervisor
Exposure to productivity meetings where budgets, schedules and other management functions are issues
Attendance of industry sponsored management courses

LEARNING OBJECTIVE #2: Administer hands-on training.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, orientation and demonstration about training principles and practices, and given a training assignment, in the work area,

DESIRED BEHAVIOR: the trainee demonstrates the ability to deliver hands-on training.

EVALUATION CRITERIA: Expected training outcomes match the training assignment. The trainee is able to transfer learning to others. The trainee demonstrates the ability to recall/relate welding technology information and apply practical experience to a training assignment. The trainee chooses an appropriate training method. Training materials match the training assignment. The trainee is able to adjust personal training style to the learning styles of the students. The trainee has selected an appropriate method of student assessment or evaluation. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to training methods and materials.
3. Provide instruction related to training and learning styles.
4. Provide instruction related to training evaluation and assessment.
5. Provide demonstrations related to the use of lecture techniques in training.
6. Provide demonstrations related to the use of demonstration techniques in training.
7. Provide experiential learning related to hands-on welder training.
8. Develop and administer formative, diagnostic and summative tests relevant to the administration of hands-on training.
9. Keep training records reflecting results of the administration of hands-on training training.

The training facility should:

1. Provide trainee with experiential learning related to hands-on training (e.g. field studies, work study or cooperative agreements).

***Note:** **This unit of instruction is designed to provide the trainee with practical application of his/her welding technology knowledge and practical welding experience. It is not necessary to provide education training on a B.S. level. Trainer education should consists of an introduction to the concepts listed in learning activities 1 - 4. These activities should be designed to give technically trained personnel a core set of competencies related to training.**

Experiential learning activities could consist of teachers aide positions in which the trainee provides or assists in the instruction of less advanced trainees (i.e. Entry Level and Level II Welders.)

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LEARNING OBJECTIVE #3: Participate in the selection and specification of equipment purchases.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, and experiential learning about equipment selection and specification, in the work area or classroom.

DESIRED BEHAVIOR: the trainee demonstrates the ability to match equipment needs to the employers unique situation.

EVALUATION CRITERIA: The trainee accurately selects and specifies equipment needs. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to the selection and specification of equipment purchases.
3. Provide instruction related to the construction of a purchase order.
4. Provide demonstrations related to the selection and specification of equipment purchases.
5. Provide demonstrations related to the construction of a purchase order.
6. Provide training exercises related to the selection and specification of equipment purchases.
7. Provide training exercises related to the construction of a purchase order.
8. Develop and administer formative, diagnostic and summative tests relevant to equipment selection and specification for purchase training.
9. Keep training records reflecting results of equipment selection and specification for purchase training.

The training facility should:

1. Provide trainee with experiential learning related to the selection and specification of equipment purchases (e.g. field studies, work study or cooperative agreements).

LEARNING OBJECTIVE #4: Estimate welding and material costs and quantities.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and experiential learning about welding and material cost and quantity estimation, in the work area,

DESIRED BEHAVIOR: the trainee demonstrates the ability to estimate welding and material costs and quantities.

EVALUATION CRITERIA: The trainee demonstrates knowledge of the competencies taught in learning activities 1 through 10 below. The trainee accurately prepares a sample estimation report. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to an introduction to estimation and the role of the estimator in the welding industry.
3. Provide instruction related to estimate preparation.
4. Provide instruction related to drawing interpretation for estimation.
5. Provide instruction related to specification package interpretation for estimation.
6. Provide instruction related to the review of joint designs for estimation.
7. Provide instruction related to the calculation of metal weight and cost for estimation.
8. Provide instruction related to the calculation of filler metal weight and cost for estimation.
9. Provide instruction related to the calculation of metal finishing and paint costs for estimation.
10. Provide instruction related to cost of finished product delivery for estimation.
11. Provide demonstrations related to the to the estimation of welding and material costs and quantities.
12. Provide training exercises related to the estimation of welding and material costs and quantities.

The training facility should:

1. Provide trainee with experiential learning related to estimation of welding and material costs and quantities. (e.g. field studies, work study or cooperative agreements).

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3.3.3 COURSE C: DOCUMENTS GOVERNING WELDING AND WELDING INSPECTION

3.3.3.1 UNIT #1: WELDING CODES AND OTHER STANDARDS*

LEARNING OBJECTIVE #1: Locate essential welding and inspection information from welding procedure specifications (WPS).

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration and applicable welding procedure specification, in the training classroom.

DESIRED BEHAVIOR: the trainee locates essential welding procedure, performance qualification and inspection criteria information.

EVALUATION CRITERIA: The trainee demonstrates an understanding of essential welding procedure, performance qualification and inspection criteria variables found within a welding procedure specification. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee relating essential welding and inspection information to classroom assignments. The trainee correctly identifies welding and inspection criteria related to performance qualification requirements. In accordance with the requirements of AWS QC12, the trainee shall pass Part B - Practical Welding Procedure Specification Interpretation (visual examination of weld samples) [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to welding procedure, performance qualification and inspection criteria information from AWS B2.1, *Standard for Welding Procedure and Performance Qualification.*
3. Provide demonstrations related to locating welding procedure, performance qualification and inspection criteria information from AWS B2.1, *Standard for Welding Procedure and Performance Qualification.*
4. Provide training exercises related to locating welding procedure, performance qualification and inspection criteria information from AWS B2.1, *Standard for Welding Procedure and Performance Qualification.*
5. Develop and administer formative or diagnostic tests relevant to welding procedure specifications.
6. Prepare trainee for Part B - Practical Welding Procedure Specification Interpretation (visual examination of weld samples) [summative testing].
7. Keep training records reflecting results of welding codes and other standards training.

*Note: **It is not expected that the trainee memorize the information found in AWS B2.1. This unit of instruction is designed to provide the trainee with an understanding of information that could be used to determine welding and inspection requirements for a particular job assignment. The open book examination for this unit will consist of a mock book of specifications constructed from portions of AWS B2.1. The trainee will be required to locate answers to questions from the book of specifications and visually examine weld specimens to determine acceptance. The book of specifications will consist of information that would be relevant to welding inspection criteria.**

LEARNING OBJECTIVE #2: Locate essential welding and inspection information from AWS D1.1, Structural Welding Code – Steel.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration and AWS D1.1, Structural Welding Code – Steel, in the training classroom.

DESIRED BEHAVIOR: the trainee locates essential welding procedure, performance qualification and inspection criteria information.

EVALUATION CRITERIA: The trainee demonstrates an understanding of essential welding procedure, performance qualification and inspection criteria variables found within AWS D1.1, *Structural Welding Code – Steel*. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee relating essential welding and inspection information to classroom assignments. The trainee correctly identifies welding and inspection criteria related to training assignments and performance qualification requirements. In accordance with the requirements of AWS QC12, the trainee shall pass Part C - Code Book Interpretation (open book examination) from the applicable sections of AWS D1.1, *Structural Welding Code – Steel* [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to welding procedure, performance qualification and inspection criteria information from AWS D1.1, *Structural Welding Code – Steel*.
3. Provide demonstrations related to locating welding procedure, performance qualification and inspection criteria information from AWS D1.1, *Structural Welding Code – Steel*.
4. Provide training exercises related to locating welding procedure, performance qualification and inspection criteria information from AWS D1.1, *Structural Welding Code – Steel*.
5. Develop and administer formative or diagnostic tests relevant to welding procedure specifications.
6. Prepare trainee for Part C - Code Book Interpretation (open book examination) from the applicable sections of AWS D1.1, *Structural Welding Code – Steel* [summative testing].
7. Keep training records reflecting results of welding codes and other standards training.

***Note:** **All training shall be in accordance with the latest version of AWS D1.1 Structural Welding Code – Steel.**

It is not expected that the trainee memorize the information found in AWS D1.1. This unit of instruction is designed to familiarize the trainee with the various sections found in AWS D1.1 and provide practical application of information that could be used to determine welding and inspection requirements for a particular job assignment from a code. The open book examination for this unit will require the trainee to locate answers to questions from AWS D1.1.

Industrial survey results indicate that the Level III – Expert Welder shall understand AWS D1.1, API 1104 and ASME Section IX. Training in all three codes is mandatory. However, on the final written examination the trainee or training facility may choose one of the codes for use in testing. AWS QC12 written examination requirements for Part C may be superceded if the training facility elects to have trainees test according to the AWS QC1, Welding Inspector Examination (see section 5).

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LEARNING OBJECTIVE #3: Locate essential welding and inspection information from API Standard 1104, Standard for Welding Pipelines and Related Facilities.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration and API Standard 1104, *Standard for Welding Pipelines and Related Facilities*, in the training classroom,

DESIRED BEHAVIOR: the trainee locates essential welding procedure, performance qualification and inspection criteria information.

EVALUATION CRITERIA: The trainee demonstrates an understanding of essential welding procedure, performance qualification and inspection criteria variables found within API Standard 1104, *Standard for Welding Pipelines and Related Facilities*. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee relating essential welding and inspection information to classroom assignments. The trainee correctly identifies welding and inspection criteria related to training assignments and performance qualification requirements. In accordance with the requirements of AWS QC12, the trainee shall pass Part C - Code Book Interpretation (open book examination) from the applicable sections of API Standard 1104, *Standard for Welding Pipelines and Related Facilities* [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to welding procedure, performance qualification and inspection criteria information from API Standard 1104, *Standard for Welding Pipelines and Related Facilities*.
3. Provide demonstrations related to locating welding procedure, performance qualification and inspection criteria information from API Standard 1104, *Standard for Welding Pipelines and Related Facilities*.
4. Provide training exercises related to locating welding procedure, performance qualification and inspection criteria information from API Standard 1104, *Standard for Welding Pipelines and Related Facilities*.
5. Develop and administer formative or diagnostic tests relevant to welding procedure specifications.
6. Prepare trainee for Part C - Code Book Interpretation (open book examination) from the applicable sections of API Standard 1104, *Standard for Welding Pipelines and Related Facilities* [summative testing].
7. Keep training records reflecting results of welding codes and other standards training.

***Note:** **All training shall be in accordance with the latest version of API Standard 1104, Standard for Welding Pipelines and Related Facilities.**

It is not expected that the trainee memorize the information found in API 1104. This unit of instruction is designed to familiarize the trainee with the various sections found in API 1104 and provide practical application of information that could be used to determine welding and inspection requirements for a particular job assignment from a code. The open book examination for this unit will require the trainee to locate answers to questions from API 1104.

Industrial survey results indicate that the Level III – Expert Welder shall understand AWS D1.1, API 1104 and ASME Section IX. Training in all three codes is mandatory. However, on the final written examination the trainee or training facility may choose one of the codes for use in testing. AWS QC12 written examination requirements for Part C may be superceded if the training facility elects to have trainees test according to the AWS QC1, Welding Inspector Examination (see section 5).

LEARNING OBJECTIVE #4: Locate essential welding and inspection information from ASME, Boiler and Pressure Vessel Code – Section IX.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration and ASME, *Boiler and Pressure Vessel Code – Section IX*, in the training classroom,

DESIRED BEHAVIOR: the trainee locates essential welding procedure, performance qualification and inspection criteria information.

EVALUATION CRITERIA: The trainee demonstrates an understanding of essential welding procedure, performance qualification and inspection criteria variables found within ASME, *Boiler and Pressure Vessel Code – Section IX*. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee relating essential welding and inspection information to classroom assignments. The trainee correctly identifies welding and inspection criteria related to training assignments and performance qualification requirements. In accordance with the requirements of AWS QC12, the trainee shall pass Part C - Code Book Interpretation (open book examination) from the applicable sections of ASME, *Boiler and Pressure Vessel Code – Section IX* [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to welding procedure, performance qualification and inspection criteria information from ASME, *Boiler and Pressure Vessel Code – Section IX*.
3. Provide demonstrations related to locating welding procedure, performance qualification and inspection criteria information from ASME, *Boiler and Pressure Vessel Code – Section IX*.
4. Provide training exercises related to locating welding procedure, performance qualification and inspection criteria information from ASME, *Boiler and Pressure Vessel Code – Section IX*.
5. Develop and administer formative or diagnostic tests relevant to welding procedure specifications.
6. Prepare trainee for Part C - Code Book Interpretation (open book examination) from the applicable sections of *ASME, Boiler and Pressure Vessel Code – Section IX* [summative testing].
7. Keep training records reflecting results of welding codes and other standards training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **All training shall be in accordance with the latest version of ASME, Boiler and Pressure Vessel Code – Section IX.**

It is not expected that the trainee memorize the information found in ASME – Section IX. This unit of instruction is designed to familiarize the trainee with the various sections found in ASME – Section IX and provide practical application of information that could be used to determine welding and inspection requirements for a particular job assignment from a code. The open book examination for this unit will require the trainee to locate answers to questions from ASME – Section IX. Address only those areas of inspection and fabrication found in section IX but make the trainee aware of the other sections that make up ASME B31.1

Industrial survey results indicate that the Level III – Expert Welder shall understand AWS D1.1, API 1104 and ASME Section IX. Training in all three codes is mandatory. However, on the final written examination the trainee or training facility may choose one of the codes for use in testing. AWS QC12 written examination requirements for Part C may be superceded if the training facility elects to have trainees test according to the AWS QC1, Welding Inspector Examination (see section 5).

3.3.3.2 UNIT #2: WELDING INSPECTION*

LEARNING OBJECTIVE #1: Interpret destructive and nondestructive test results.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, destructive and nondestructive testing guidelines from a code or other standard, protective clothing and equipment, visual examination tools and test specimens or radiographs, in the classroom,

DESIRED BEHAVIOR: the trainee interprets destructive and nondestructive test results.

EVALUATION CRITERIA: The trainee relates concepts and interprets destructive and nondestructive test results. The objective is performed as required during the length of the program. In accordance with the requirements of AWS QC12, the trainee shall pass Part A - Welding Fundamentals and Safety and Part B - Practical Welding Specification Interpretation (visual examination of weld samples) of a written examination (summative testing).

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction about nondestructive examination from AWS Welding Handbook, Vol. 1, 8th Ed., Chapter 15, *Inspection*, Nondestructive Examination, ANSI/AWS B1.11, *Guide for the Visual Inspection of Welds* and ANSI/AWS B 1.10, *Guide for the Nondestructive Inspection of Welds*.
3. Provide instruction about destructive tests from AWS Welding Handbook, Vol. 1, 8th Ed., Chapter 15, *Inspection*, Destructive Tests and ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.
4. Provide instruction about common cutting surface and edge discontinuities from AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces*.
5. Provide demonstrations related to the use of visual examination methods and tools.
6. Provide demonstrations related to calculations and measurement of tension test specimens.
7. Provide demonstrations related to the interpretation of bend test results.
8. Provide demonstrations related to the interpretation of penetrant test results.
9. Provide demonstrations related to the interpretation of magnetic particle test results.
10. Provide demonstrations related to the interpretation of ultrasonic test results.
11. Provide demonstrations related to the interpretation of radiographic test results.
12. Provide training exercises related to the use of visual examination methods and tools.
13. Provide training exercises related to calculations and measurement of tension test specimens.
14. Provide training exercises related to the interpretation of bend test results.
15. Provide training exercises related to the interpretation of penetrant test results.
16. Provide training exercises related to the interpretation of magnetic particle test results.
17. Provide training exercises related to the interpretation of ultrasonic test results.
18. Provide training exercises related to the interpretation of radiographic test results.
19. Observe trainee following safe visual examination practices.
20. Provide feedback to trainee about his/her interpretation diagnosis.
21. Develop and administer formative or diagnostic tests relevant to destructive and non destructive testing.

22. Prepare trainee for Part A - Welding Fundamentals and Safety and Part B - Practical Welding Specification Interpretation (visual examination of weld samples) of the written examination [summative testing].
23. Keep training records reflecting results of destructive and nondestructive testing training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **Elements of experiential learning for welding inspection training should include:**

- **Time spent in Welding Specialties, Production Areas (hands-on area) and Inspection Areas (quality assurance)**
- **Work with acceptance codes that are required by each job**
- **Interpretation of welding procedures and required codes**
- **Work with a proven, experienced inspector**
- **Work at more than one area of inspection during experiential learning (e.g. piping, vessel, structural, etc.)**
- **Performance of visual examination, bend testing, penetrant testing and magnetic particle testing**
- **Monitoring and examining work performed by tackers, welding operators, or welders**
- **Recording inspection results in such a way that the work personally inspected may be identified, and the inspection findings accurately reported**

LEARNING OBJECTIVE #2: Prepare inspection reports.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, inspection guidelines from a welding procedure specification, code or other standard, an appropriate form or report format, in the classroom and work area,

DESIRED BEHAVIOR: the trainee records data relevant to the interpretation of nondestructive and destructive test results.

EVALUATION CRITERIA: The trainee accurately records inspection information on a form or report. The information is reviewed and accepted by the instructor. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to the use and importance of inspection forms and report formats found in the welding industry.
3. Provide instruction related to various inspection forms and report formats found in the welding industry.
4. Provide demonstrations related to the completion of various inspection forms and report formats found in the welding industry.
5. Provide training exercises related to the completion of various inspection forms and report formats found in the welding industry.
6. Provide feedback to trainee about his/her visual examination diagnosis.
7. Develop and administer formative or diagnostic and summative tests relevant to the preparation of inspection reports.
8. Keep training records reflecting results of inspection report preparation.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).

LEARNING OBJECTIVE #3: Perform visual examination.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, visual examination guidelines from a welding procedure specification, code or other standard, protective clothing and equipment, visual examination tools, cutting and welding specimens, in the work area,

DESIRED BEHAVIOR: the trainee performs visual examination of cutting and welding sample specimens.

EVALUATION CRITERIA: Sample specimens are visually examined by the trainee according to welding procedures specifications, code or other standard information. Results are reported by the trainee to the instructor who verifies accuracy of findings. The objective is performed on a routine basis during the length of the program. In accordance with the requirements of AWS QC12, the trainee shall pass Part B - Practical Welding Procedure Specification Interpretation (visual examination of weld samples) [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide demonstrations related to the visual examination of arc cut, oxyfuel gas cut and weld specimens.
3. Provide training exercises related to the visual examination of arc cut, oxyfuel gas cut and weld specimens.
4. Observe trainee following safe visual examination practices.
5. Observe trainee performing visual examination.
6. Provide feedback to trainee about his/her visual examination diagnosis.
7. Develop and administer formative or diagnostic tests relevant to visual examination of arc cut, oxyfuel gas cut and weld specimens.
8. Prepare trainee for AWS QC12, Part B - Practical Welding Procedure Specification Interpretation elements of written examination [summative testing].
9. Keep training records reflecting results of visual examination training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **This unit of instruction is designed to provide the trainee with practical application of the concepts taught in 3.3.3.1 UNIT #1: WELDING CODES AND OTHER STANDARDS. The open book examination for this unit will consist of a mock book of welding procedure specifications. The trainee will be required to locate answers to questions from the book of specifications and visually examine weld specimens to determine acceptance. The book of specifications will consist of information that would be relevant to welding inspection criteria.**

The instructor should incorporate visual examination into the training program and have Level III trainees routinely examine actual cutting and welding samples from the welding and cutting work area. Practice should include the use of a variety of acceptance criteria from various WPS's, codes and other standards.

AWS QC12 written examination requirements for Part B may be superceded if the training facility elects to have trainees test according to the AWS QC1, Welding Inspector Examination (see section 5).

LEARNING OBJECTIVE #4: Perform bend testing.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, bend testing acceptance criteria guidelines from a welding procedure specification, code or other standard, protective clothing and equipment, bend testing equipment, visual examination tools and welding specimens, in the work area,

DESIRED BEHAVIOR: the trainee prepares, bend tests and visually examines weld specimens according to the acceptance criteria of a welding procedure specification, code or other standard.

EVALUATION CRITERIA: Sample specimens are prepared, bend tested and visually examined by the trainee according to welding procedures specifications, code or other standard information. Results are reported by the trainee to the instructor who verifies accuracy of findings. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to the preparation, bend testing and visual examination of weld specimens.
3. Provide demonstrations related to the preparation, bend testing and visual examination of weld specimens.
4. Provide training exercises related to the preparation, bend testing and visual examination of weld specimens.
5. Observe trainee following safe preparation, bend testing and visual examination of weld specimens.
6. Observe trainee performing preparations, bend testing and visual examination of weld specimens.
7. Provide feedback to trainee about his/her visual examination diagnosis.
8. Develop and administer formative or diagnostic and summative tests relevant to the preparation, bend testing and visual examination of weld specimens.
9. Keep training records reflecting results of bend test training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **This unit of instruction is designed to provide the trainee with practical application of the concepts taught in 3.3.3.1 UNIT #1: WELDING CODES AND OTHER STANDARDS and 3.3.3.2 UNIT #2: WELDING INSPECTION, LEARNING OBJECTIVE #1: Perform visual examination. Practice should include the use of a variety of acceptance criteria from various WPS's, codes and other standards.**

The instructor should incorporate bend testing and visual examination into the training program. Level III trainees should routinely prepare, bend test and visually examine weld specimens from the welding work area.

LEARN.NG OBJECTIVE #5: Perform penetrant testing.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, penetrant testing acceptance criteria guidelines from a welding procedure specification, code or other standard, protective clothing and equipment, penetrant testing equipment, visual examination tools and welding specimens, in the work area.

DESIRED BEHAVIOR: the trainee prepares, penetrant tests and visually examines weld specimens according to the acceptance criteria of a welding procedure specification, code or other standard.

EVALUATION CRITERIA: Sample specimens are prepared, penetrant tested and visually examined by the trainee according to welding procedures specifications, code or other standard information. Results are reported by the trainee to the instructor who verifies accuracy of findings. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to the preparation, penetrant testing and visual examination of weld specimens.
3. Provide demonstrations related to the preparation, penetrant testing and visual examination of weld specimens.
4. Provide training exercises related to the preparation, penetrant testing and visual examination of weld specimens.
5. Observe trainee following safe preparation, penetrant testing and visual examination of weld specimens.
6. Observe trainee performing preparations, penetrant testing and visual examination of weld specimens.
7. Provide feedback to trainee about his/her visual examination diagnosis.
8. Develop and administer formative or diagnostic and summative tests relevant to the preparation, penetrant testing and visual examination of weld specimens.
9. Keep training records reflecting results of penetrant test training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).
2. Provide trainee with experiential learning related to penetrant testing equipment operation (e.g. field studies, work study or manufacturer hands-on type demonstrations of various testing equipment used in welded metal fabrication).

***Note:** **This unit of instruction is designed to provide the trainee with practical application of the concepts taught in 3.3.3.1 UNIT #1: WELDING CODES AND OTHER STANDARDS and 3.3.3.2 UNIT #2: WELDING INSPECTION, LEARNING OBJECTIVE #1: Perform visual examination. Practice should include the use of a variety of acceptance criteria from various WPS's, codes and other standards. Level III trainees should routinely prepare, penetrant test and visually examine weld specimens from the welding work area during this period of instruction.**

LEARNING OBJECTIVE #6: Perform magnetic particle testing.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, magnetic particle testing acceptance criteria guidelines from a welding procedure specification, code or other standard, protective clothing and equipment, magnetic particle testing equipment, visual examination tools and welding specimens, in the work area.

DESIRED BEHAVIOR: the trainee prepares, magnetic particle tests and visually examines weld specimens according to the acceptance criteria of a welding procedure specification, code or other standard.

EVALUATION CRITERIA: Sample specimens are prepared, magnetic particle tested and visually examined by the trainee according to welding procedures specifications, code or other standard information. Results are reported by the trainee to the instructor who verifies accuracy of findings. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to the preparation, magnetic particle testing and visual examination of weld specimens.
3. Provide demonstrations related to the preparation, magnetic particle testing and visual examination of weld specimens.
4. Provide training exercises related to the preparation, magnetic particle testing and visual examination of weld specimens.
5. Observe trainee following safe preparation, magnetic particle testing and visual examination of weld specimens.
6. Observe trainee performing preparations, magnetic particle testing and visual examination of weld specimens.
7. Provide feedback to trainee about his/her visual examination diagnosis.
8. Develop and administer formative or diagnostic and summative tests relevant to the preparation, magnetic particle testing and visual examination of weld specimens.
9. Keep training records reflecting results of magnetic particle test training.

The training facility should:

1. Provide trainee with experiential learning related to welding inspection training in the welding industry (e.g. field studies, work study or cooperative agreements).
2. Provide trainee with experiential learning related to magnetic particle testing equipment operation (e.g. field studies, work study or manufacturer hands-on type demonstrations of various testing equipment used in welded metal fabrication).

*Note: **This unit of instruction is designed to provide the trainee with practical application of the concepts taught in 3.3.3.1 UNIT #1: WELDING CODES AND OTHER STANDARDS and 3.3.3.2 UNIT #2: WELDING INSPECTION, LEARNING OBJECTIVE #1: Perform visual examination. Practice should include the use of a variety of acceptance criteria from various WPS's, codes and other standards. Level III trainees should routinely prepare, magnetic particle test and visually examine weld specimens from the welding work area during this period of instruction.**

3.3.4 COURSE D: WELDED METAL FABRICATION*

LEARNING OBJECTIVE #1: Troubleshoot fabrication setups and processes.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, troubleshooting guidelines, troubleshooting equipment and tools, a job assignment or practices exercises, in the classroom and work area,

DESIRED BEHAVIOR: the trainee analyzes and corrects performance problems during fabrication setup and process operation.

EVALUATION CRITERIA: The trainee's analysis and corrective measures solve the performance problem. The trainee is observed locating, analyzing and solving performance problems during the course of troubleshooting operations. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction related to systematic approaches for troubleshooting fabrication setups and processes.
3. Provide demonstration related to systematic approaches for troubleshooting fabrication setups and processes.
4. Provide training exercises related to systematic approaches for troubleshooting fabrication setups and processes.
5. Develop and administer formative or diagnostic and summative tests relevant to troubleshooting fabrication setups and processes.
6. Keep training records reflecting results of troubleshooting fabrication setups and processes training.

The training facility should:

1. Provide trainee with experiential learning related to welded metal fabrication training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **Elements of experiential learning for welded metal fabrication training should include:**
Time spent in Welding Specialties, Production Areas (hands-on area) and Inspection Areas (quality assurance)
Work with acceptance codes that are required by each job
Work performed from complex drawings (multiple page, multiple view) to fabricate weldments
Interpretation of welding procedures and required codes
Work with a proven, experienced layout or fitup person
Work at more than one area of fabrication during experiential learning (e.g. sheet metal, structural, pipe)
Layout and fitup duties that include: all previously attained competencies from Level I and Level II training, troubleshooting fabrication setups and processes, fabrication of jigs and fixtures; preparation of cutting lists, sequencing of parts for fabrication and compensation for distortion and shrinkage

LEARNING OBJECTIVE #2: Interpret welding, nondestructive examination and piping symbols.

PERFORMANCE CONDITIONS: Provided with instruction and demonstration, drawings or sketches with welding, nondestructive examination and piping symbols and supplementary data, in the work area or classroom.

DESIRED BEHAVIOR: the trainee will locate, review and determine welding, nondestructive examination and piping requirements.

EVALUATION CRITERIA: The trainee identifies welding requirements according to welding, nondestructive examination and piping symbols and supplementary data information. The objective is practiced on a routine basis over the length of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the welding and nondestructive symbol elements from the related sections of ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing and Nondestructive Examination* and piping symbol element for Part A - Welding Fundamentals and Safety of written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction in welding symbol interpretation.
3. Provide instruction in nondestructive examination symbol interpretation.
4. Provide instruction in piping symbol interpretation.
5. Demonstrate welding, nondestructive and piping symbol interpretation.
6. Provide training exercises related to welding, nondestructive examination and piping symbol interpretation.
7. Introduce related terms and definitions.
8. Observe trainee carrying out welding, nondestructive examination, and piping requirements from welding symbol information.
9. Develop and administer formative or diagnostic tests relevant to welding, nondestructive examination and piping symbol information.
10. Prepare trainee for the welding and nondestructive symbol elements from the related sections of ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing and Nondestructive Examination* and piping symbol elements for Part A - Welding Fundamentals and Safety of written examination [summative testing].
11. Keep training records reflecting results of welding, nondestructive examination and piping symbol interpretation requirements.

The training facility should:

1. Provide trainee with experiential learning related to welded metal fabrication training in the welding industry (e.g. field studies, work study or cooperative agreements).

LEARNING OBJECTIVE #3: Layout parts using advanced measurement practices.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, mathematical charts, formulas, an appropriate calculator, and a work assignment.

DESIRED BEHAVIOR: the trainee performs calculations related to part preparation and component assembly during various stages of layout and fitup.

EVALUATION CRITERIA: The trainee's completed product meets the design specifications for a particular job assignment. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide demonstrations related to the use of mathematical formulas to determine allowances for bending operations.
2. Provide demonstrations related to the use of setback charts for sheet or plate bending operations.
3. Provide demonstrations related to the use of geometric principles to determine angles, intersecting lines, cutouts, positions and lengths, during layout or fitup operations.
4. Provide demonstrations related to the use of trigonometric functions to determine angles, intersecting lines, cutouts, positions and lengths, during layout or fitup operations.
5. Provide demonstrations related to the use of trigonometry tables or calculator functions to determine angles, intersecting lines, cutouts, positions and lengths during layout or fitup operations.
6. Provide training exercises related to the use of mathematical formulas to determine allowances for bending operations.
7. Provide training exercises related to the use of setback charts for sheet or plate bending operations.
8. Provide training exercises related to the use of geometric principles to determine angles, intersecting lines, cutouts, positions and lengths during layout or fitup operations.
9. Provide training exercises related to the use of trigonometric functions to determine angles, intersecting lines, cutouts, positions and lengths during layout or fitup operations.
10. Provide training exercises related to the use of trigonometry tables or calculator functions to determine angles, intersecting lines, cutouts, positions and lengths during layout or fitup operations.
11. Develop and administer formative or diagnostic and summative tests relevant to advanced measurement practices.
12. Keep records reflecting successful completion of advanced measurement practices training.

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LEARNING OBJECTIVE #4: Fabricate weldments from complex drawings*.

PERFORMANCE CONDITIONS: Provided with a period of instructional reinforcement, protective clothing and equipment, various shop equipment and accessories, a drawing package and a job assignment, in the work area.

DESIRED BEHAVIOR: the trainee completes various job assignments from drawing packages.

EVALUATION CRITERIA: The trainee's completed project matches drawing specifications. The trainee has selected the proper layout and fitup methods, shop equipment, accessories and tools. The trainee is observed by the instructor completing tasks during various stages of the job assignment. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Reinforce shop equipment safe operating procedures.
3. Reinforce previous drawing, layout and fitup training.
4. Provide instruction related to fabrication methods and practices.
5. Provide instruction related to the interpretation of multiple view, multiple page drawings with specification packages from a variety of industries (including sheet metal, structural and pipe).
6. Provide trainee with fabrication exercises.
7. Observe trainee following safe practices.
8. Observe trainee during setup, layout and fitup phases of fabrication
9. Visually inspect trainee's completed work assignments.
10. Develop and administer formative or diagnostic and summative tests relevant to fabrication from complex drawings.
11. Keep training records reflecting results of fabrication from complex drawings training and performance exercises.

The training facility should:

1. Provide trainee with experiential learning related to fabrication from complex drawings (e.g. field studies or work study in welded metal fabrication).

*Note: **Some type of project should be included in laboratory exercises that is relevant to the construction of jigs and fixtures used during layout and fitup of production runs. (e.g. have the trainee layout a hand rail sections [using soapstone lines not material] on a work area table and build a fixture to hold it. Laying out a project on the table also assists in accurately estimating the linear footage of product forms or size of plate required for a job. This method also aids in the reduction of wasted material and provides the instructor with a means to check the accuracy of the trainee's layout.**

Fabrication training may be substituted with 6 months documented employment in related subjects or through cooperative work agreements (school-to-work). It is strongly recommended that this type of training be instituted in training facilities that are unable to provide all of the necessary materials, equipment and tools or because of space constraints the area necessary to carry out this assignment. Cooperative work agreements for fabrication training should include all elements from Entry Level through Level III training.

LEARNING OBJECTIVE #5: Fabricate jigs and fixtures.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, protective clothing and equipment, the necessary materials, equipment and tools, and a job assignment, in the work area.

DESIRED BEHAVIOR: the trainee constructs jigs and fixtures for various job assignments.

EVALUATION CRITERIA: The trainee's completed projects are adequate for their intended service. The objective is performed as required during the length of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction related to the fabrication of jigs and fixtures.
3. Provide demonstrations related to the fabrication of jigs and fixtures.
4. Provide training exercises related to the fabrication of jigs and fixtures.
5. Observe trainee following safe practices.
6. Observe trainee during setup, layout and fitup phases of fabrication.
7. Visually inspect trainee's completed work assignments.
8. Develop and administer formative or diagnostic and summative tests relevant to the fabrication of jigs, and fixtures.

The training facility should:

1. Provide trainee with experiential learning related to welded metal fabrication training in the welding industry (e.g. field studies, work study or cooperative agreements).

***Note:** **Some type of project should be included in laboratory exercises that is relevant to the construction of jigs and fixtures used during layout and fitup of production runs. (e.g. have the trainee layout a hand rail sections [using soapstone lines not material] on a work area table and build a fixture to hold it. This learning objective is designed to be used in conjunction with drawing interpretation as well as layout and fitup.**

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3.3.5 COURSE E: WELDING METALLURGY

3.3.5.1 UNIT #1: (no units this course)

LEARNING OBJECTIVE #1: Apply principles of welding metallurgy to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and appropriate welding metallurgy training material, in the classroom and work area.

DESIRED BEHAVIOR: the trainee relates welding metallurgical concepts to welding, fabrication and inspection situations.

EVALUATION CRITERIA: The trainee relates concepts of welding metallurgy to welding, fabrication and inspection situations. Possesses technical knowledge related to general metallurgy, welding metallurgy and weldability testing. In accordance with the requirements of AWS QC12, the trainee shall pass the welding metallurgy element from the applicable sections of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy* of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide an introduction to welding metallurgy from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 4, *Welding Metallurgy*.
3. Provide instruction about general metallurgy from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 4, *Welding Metallurgy*.
4. Provide instruction about the metallurgy of welding from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 4, *Welding Metallurgy*.
5. Provide instruction about weldability testing from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 4, *Welding Metallurgy*.
6. Introduce related terms and definitions.
7. Provide training exercises that require the trainee to relate concepts of welding metallurgy to various training situations.
8. Develop and administer formative or diagnostic tests relevant to welding metallurgy training.
9. Prepare trainee for the welding metallurgy element of of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
10. Keep training records reflecting results of welding metallurgy training.

LEARNING OBJECTIVE #2: Apply principles of metal properties to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and appropriate properties of metals training material, in the classroom or work area,

DESIRED BEHAVIOR: the trainee relates properties of metals principles to welding, fabrication and inspection situations.

EVALUATION CRITERIA: The trainee relates the effects of welding on the properties of metals to welding, fabrication and inspection situations. In accordance with the requirements of AWS QC12, the trainee shall pass the properties of metals element from the applicable section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 5, *Design For Welding*, Properties of Metals, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction about metal properties from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 5, *Design For Welding*, Properties of Metals.
3. Provide demonstrations related to the effects of welding on the properties of metals.
4. Introduce related terms and definitions.
5. Provide training exercises that require the trainee to relate principles of metal properties to various training situations.
6. Develop and administer formative or diagnostic tests relevant to the properties of metals training.
7. Prepare trainee for the properties of metals element of closed book examination [summative testing].
8. Keep training records reflecting results of properties of metals training.

LEARNING OBJECTIVE #3: Apply principles related to residual stress and distortion to welding, fabrication and inspection.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and appropriate residual stress and distortion training material, in the classroom.

DESIRED BEHAVIOR: the trainee relates residual stress and distortion principles to welding, fabrication and inspection situations.

EVALUATION CRITERIA: The trainee relates the effects of residual stress and distortion to welding, fabrication and inspection situations. The trainee is observed taking corrective actions to minimize residual stress and control distortion during fabrication and welding assignments over the length of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the residual stress and distortion element from the applicable section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 7, *Residual Stresses and Distortion*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction about residual stress and distortion from the related section of AWS Welding Handbook, Volume 1, Eighth Ed, Chapter 7, *Residual Stresses and Distortion*.
3. Provide demonstrations related to the effects of residual stress and distortion in welding.
4. Provide demonstrations related to the reduction of residual stresses in welding.
5. Provide demonstrations related to the control of distortion in welding.
6. Provide demonstrations related to the correction of distortion in welding.
7. Introduce related terms and definitions.
8. Provide training exercises related to the control of distortion in welding.
9. Provide training exercises related to the correction of distortion in welding.
10. Provide training exercises that require the trainee to relate principles of residual stress and distortion to various training situations.
11. Develop and administer formative or diagnostic tests relevant to residual stress and distortion training.
12. Prepare trainee for the residual stress and distortion element from the applicable section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 7, *Residual Stresses and Distortion*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
13. Keep training records reflecting results of residual stress and distortion training.

***Note:** **This unit of instruction is designed to provide the trainee with a thorough understanding about residual stresses and distortion The trainee should be able to recognize techniques that can be used to reduce residual stresses and control or correct distortion.**

LEARNING OBJECTIVE #4: Apply principles related to alloy weldability to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and appropriate alloy weldability training material, in the classroom or work area,

DESIRED BEHAVIOR: the trainee applies alloy weldability principles to welding, fabrication and inspection.

EVALUATION CRITERIA: The trainee relates alloy weldability principles to welding, fabrication and inspection. In accordance with the requirements of AWS QC12, the trainee shall pass the weldability element from the applicable section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction about the weldability of steel alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
3. Provide instruction about the weldability of aluminum alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
4. Provide instruction about the weldability of magnesium alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
5. Provide instruction about the weldability of copper alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
6. Provide instruction about the weldability of nickel-base alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
7. Provide instruction about the weldability of titanium alloys from the related section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys.
8. Provide demonstrations related to the weldability of one alloy from each of the alloy groups listed in learning activities 1 - 7 above..
9. Provide training exercises that require the trainee to relate principles alloy weldability to various training situations.
10. Develop and administer formative or diagnostic tests relevant to alloy weldability training.
11. Prepare trainee for the weldability element from the applicable section of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
12. Keep training records reflecting results of alloy weldability training.

3.3.6 COURSE F: ARC WELDING PRINCIPLES & PRACTICES

3.3.6.1 UNIT #1: WELDING THEORY

LEARNING OBJECTIVE #1: Apply principles of joint design and preparation to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, appropriate joint design and preparation training material, in the classroom or work area.

DESIRED BEHAVIOR: the trainee applies principles of joint design and preparation to welding, fabrication and inspection.

EVALUATION CRITERIA: The trainee relates joint design principles and joint preparation to welding, fabrication and inspection situations. In accordance with the requirements of AWS QC12, the trainee shall pass the joint design element from the applicable sections of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 5, *Design for Welding* and AWS Volume 2, Eighth Ed., Chapters 2 - 5, Joint Design, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to joint design from AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 5, *Design for Welding*.
2. Provide instruction related to joint design for shielded metal arc welding from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 2, *Shielded Metal Arc Welding*, Joint Design and Preparation.
3. Provide instruction related to joint design for gas tungsten arc welding from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 3, *Gas Tungsten Arc Welding*, Joint Design.
4. Provide instruction related to joint design for gas metal arc welding from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 4, *Gas Metal Arc Welding*, Applications and ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*.
5. Provide instruction related to joint design for flux cored arc welding from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 5, *Flux Cored Arc Welding*, Joint Designs and Welding Procedures.
6. Provide demonstrations related to joint design and preparation for welding, fabrication and inspection.
7. Provide training exercises related to joint design and preparation for welding, fabrication and inspection.
8. Develop and administer formative or diagnostic tests relevant to joint design and preparation training.
9. Prepare trainee for the joint design element of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
10. Keep training records reflecting results of joint design and preparation training.

LEARNING OBJECTIVE #2: Apply principles of material selection to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and practice, a material list, suitable measuring tool and various base metals for a job assignment, in the classroom or work area.

DESIRED BEHAVIOR: the trainee selects, identifies and recognizes the use of various commercial alloys and product forms during welding, fabrication and inspection.

EVALUATION CRITERIA: Material requirements are identified and correctly selected. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee selecting material according to job assignment requirements. The trainee correctly identifies material type and size specifications for a variety of product forms. In accordance with the requirements of AWS QC12, the trainee shall pass the material identification element of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to material storage and retrieval systems.
2. Provide instruction related to material identification, selection and use for commonly used commercial alloys.
3. Provide instruction related to the use of resource material to select common product forms.
4. Provide instruction related to the identification, selection and usage of common product forms.
5. Provide instruction related to selecting multiple parts from a single product form.
6. Provide demonstration related to material identification, selection and use for commonly used commercial alloys.
7. Provide demonstration related to the use of resource material to select common product forms.
8. Provide demonstration related to the identification, selection and usage of common product forms.
9. Provide demonstration related to selecting multiple parts from a single product form.
10. Provide training exercises related to material identification, selection and use for commonly used commercial alloys.
11. Provide training exercises related to the use of resource material to select common product forms.
12. Provide training exercises related to the identification, selection and usage of common product forms.
13. Provide training exercises related to selecting multiple parts from a single product form.
14. Develop and administer formative or diagnostic tests relevant to material selection.
15. Prepare trainee for the material identification element of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
16. Keep training records reflecting results of material selection training.

The training facility should:

1. 1. Provide trainee with experiential learning related to material selection, identification and use training in the welding industry (e.g. field studies, work study or cooperative agreements).

LEARNING OBJECTIVE #3: Apply principles of welding applications to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and practice, suitable arc welding applications training materials, in the classroom or work area.

DESIRED BEHAVIOR: the trainee is able to match welding applications to welding, fabrication and inspection situations.

EVALUATION CRITERIA: The trainee has selected the correct welding application for the intended service. The objective is practiced on a routine basis over the length of the program. The instructor observes the trainee selecting welding applications according to job assignment requirements. The trainee correctly selects welding applications for a variety of job assignments. In accordance with the requirements of AWS QC12, the trainee shall pass the applications element of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to shielded metal arc welding application from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 2, *Shielded Metal Arc Welding*, Applications.
2. Provide instruction related to gas tungsten arc welding application from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 2, *Gas Tungsten Arc Welding*, Applications.
3. Provide instruction related to gas metal arc welding application from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 4, *Gas Metal Arc Welding*, Applications and Special Applications.
4. Provide instruction related to flux cored arc welding application from AWS Welding Handbook, Volume 2, Eighth Ed., Chapter 2, *Flux Cored Arc Welding*, Principal Applications.
5. Provide instruction related to steel and steel alloy welded applications.
6. Provide instruction related to aluminum and aluminum alloy welded applications from AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 1, *Aluminum and Aluminum Alloys*.
7. Provide instruction related to magnesium and magnesium alloy welded applications from AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 2, *Magnesium and Magnesium Alloys*.
8. Provide instruction related to copper and copper alloy welded applications from AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 3, *Copper and Copper Alloys*.
9. Provide instruction related to nickel and nickel alloy welded applications from AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 1, *Nickel and Cobalt Alloys*.
10. Provide demonstrations related to the selection of welding applications for material and service conditions related to welding, fabrication and inspection situations.
11. Provide training exercises related to the selection of welding applications for material and service conditions related to welding, fabrication and inspection situations.
12. Develop and administer formative or diagnostic tests relevant to welding applications.
13. Prepare trainee for the welding applications element of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
14. Keep training records reflecting results of welding applications training.

LEARNING OBJECTIVE #4: Apply principles of weld quality and repairs to welding, fabrication and inspection.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration and practice, suitable weld quality and repair training materials, and the necessary inspection and repair tools, in the classroom or work place

DESIRED BEHAVIOR: the trainee correctly identifies weld quality according to acceptance guidelines, and suggests or preforms repairs to correct unfavorable conditions.

EVALUATION CRITERIA: The trainee's visual examination and suggested or performed repairs correct unfavorable conditions according to acceptance guidelines. The trainee's actions are evaluated by the instructor and feedback is provided. The trainee practices the objective on a routine basis over the length of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the terms and definitions element of Part A - Welding Fundamentals and Safety and the visual examination element of Part B - Practical Welding Specification Interpretation (visual examination of weld samples) of a written examination (summative testing).

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to weld quality from the applicable sections of AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 11, *Weld Quality* and AWS B1.11, *Guide for the Visual Inspection of Welds*.
2. Provide instruction related to weld repairs from the applicable sections of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 9, *Maintenance and Repair Welding*.
3. Provide demonstrations related to weld quality and weld repairs
4. Introduce related terms and definitions.
5. Provide training exercises related to weld quality and weld repairs
6. Develop and administer formative or diagnostic tests relevant to weld quality and repairs.
7. Prepare trainee for the terms and definitions element of Part A - Welding Fundamentals and Safety and the visual examination element of Part B - Practical Welding Specification Interpretation (visual examination of weld samples) of a written examination (summative testing).
8. Keep training records reflecting results of weld quality and repair training.

The training facility should:

1. Provide trainee with experiential learning related to welding quality and repairs training in the welding industry (e.g. field studies, work study or cooperative agreements).

3.3.6.2 UNIT #2: SHIELDED METAL ARC WELDING (SMAW)

LEARNING OBJECTIVE #1: Perform safety inspections of equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration and safety inspection guidelines, protective clothing and equipment, shielded arc welding equipment, accessories and hand tools, in the work area.

DESIRED BEHAVIOR: the trainee performs safety inspections of protective equipment and clothing, shielded metal arc welding equipment and accessories, required tools and the work area.

EVALUATION CRITERIA: The trainee's protective equipment and clothing, work area, welding equipment, accessories, and hand tools meet safety requirements. Hazard warnings are communicated to others in the immediate area prior to the start of shielded metal arc welding operations. In the course of daily operations, the trainee is observed following safe practices. The objective is performed as required during the shielded metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the arc welding safety element from the related sections of ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes* of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide a safety tour and orientation for shielded metal arc welding equipment and accessories.
3. Reinforce previous instruction from ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part I – General Aspects.
4. Provide instruction related to, ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
5. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
6. Provide demonstrations related to routine a safety inspections of protective equipment and clothing, shielded metal arc welding equipment and accessories, required tools and the work area.
7. Introduce related terms and definitions.
8. Observe trainee conducting safety inspections.
9. Observe trainee following safe practices.
10. Observe trainee using proper terms and definitions.
11. Develop and administer formative or diagnostic tests relevant to safe arc welding practices.
12. Prepare trainee for the arc welding safety portion of a closed book written examination from the related sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*.
13. Keep records reflecting successful completion of SMAW safe practices training.

LEARNING OBJECTIVE #2 Make minor external repairs to equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and repair materials, equipment or tools, in the work area,

DESIRED BEHAVIOR: the trainee will make minor external repairs to shielded metal arc welding equipment and accessories.

EVALUATION CRITERIA: The trainee's repairs on arc welding equipment and accessories are made in accordance with the manufacturer's recommendations and the institution's repair policy. The correct repair materials, equipment, or tools are selected. The assignment is completed in a timely manner. The objective is performed as required during the shielded metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the shielded metal arc welding component identification element from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes,* of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to shielded metal arc welding equipment and accessory component identification
3. Provide instruction related to minor external repairs to shielded metal arc welding equipment and accessories.
4. Provide demonstrations related to shielded metal arc welding equipment and accessory component identification.
5. Provide demonstrations related to minor external repairs on shielded metal arc welding equipment and accessories.
6. Introduce related terms and definitions.
7. Provide trainee with repair assignments when required.
8. Observe trainee following safe repair practices.
9. Observe trainee using proper terms and definitions.
10. Develop and administer formative or diagnostic tests relevant to shielded metal arc welding component identification.
11. Prepare trainee for the shielded metal arc welding component identification portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes.*
12. Keep training records reflecting results of shielded metal arc welding component identification.

LEARNING OBJECTIVE #3: Set up components and accessories of a complete shielded metal arc welding system.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, verbal or written instructions, protective clothing and equipment, shielded metal arc welding equipment, accessories and hand tools in the work area.

DESIRED BEHAVIOR: the trainee will set up components and accessories of a complete shielded metal arc welding system.

EVALUATION CRITERIA: The shielded metal arc welding system is operable. Verbal or written instructions are understood. All components and accessories of the system have been installed according to manufacturer's recommendations. The objective is performed as required during the shielded metal arc welding portion of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction in component and accessory setup of a complete shielded metal arc welding system.
3. Provide demonstrations of component and accessory setup of a complete shielded metal arc welding system.
4. Provide training exercises for component and accessory setup of a complete shielded metal arc welding system.
5. Observe trainee following safe practices.
6. Observe trainee setting up the components and accessories of a shielded metal arc welding system.
7. Develop and administer formative or diagnostic tests relevant to component and accessory setup of a complete shielded metal arc welding system.
8. Keep training records reflecting results of component and accessory setup of a complete shielded metal arc welding system.

***Note:** **This unit of instruction is designed to provide the trainee with a thorough understanding about SMAW system setup. This does not include the internal setup of the power source. This learning objective could be coupled with performance qualifications (the trainee sets up the system and then operates it as part of performance qualifications). This learning objective is also suited to tear down and setup. Have one trainee tear down the components and accessories and another set them back up.**

LEARNING OBJECTIVE #4: Set up for shielded metal arc welding operations.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, shielded metal arc welding equipment, accessories, hand tools, base metal and E3XX-15/16, E6010 or E6011, and E7018 electrodes, in the work area,

DESIRED BEHAVIOR: the trainee will set up and prepare to perform shielded metal arc welding operations on carbon steel and stainless steel.

EVALUATION CRITERIA: The trainee is prepared to weld. Verbal or written instructions are understood. Protective clothing and equipment are suitable for job requirements. The proper hand tools, equipment, base metal, and electrodes are selected. Shielded metal arc welding equipment is set up and adjusted for the proper current and polarity. Parts are assembled and preheated according to job requirements. The objective is performed on a routine basis during the shielded metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the shielded metal arc welding principles of operation, base/filler metal selection and identification elements from the related sections of AWS Welding Handbook, Volume 1, Eighth Ed., *Welding Technology*, Volume 2, Eighth Ed., *Welding Processes* and ANSI/AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding* and ANSI/AWS A5.4, *Specification for Corrosion-Resisting Chromium and Chromium Nickel Steel Covered Electrodes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction in AC/DC principles.
3. Provide instruction in shielded metal arc welding principles of operation.
4. Provide instruction in carbon steel and stainless steel shapes, identification and selection.
5. Provide instruction in the shielded metal arc welding filler metal identification and selection.
6. Provide demonstrations related to shielded metal arc welding equipment and accessory set up.
7. Introduce related terms and definitions.
8. Provide trainee with practice setting up shielded metal arc welding equipment and accessories.
9. Observe trainee following safe practices.
10. Observe trainee using proper terms and definitions.
11. Observe trainee setting up shielded metal arc welding equipment and accessories.
12. Develop and administer formative or diagnostic tests relevant to AC/DC principles, shielded metal arc welding principles of operation and base/filler metal identification and selection.
13. Prepare trainees for the shielded metal arc welding principles of operation, carbon steel and stainless steel base/filler metal selection and identification portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 1, Eighth Ed., *Welding Technology*, Volume 2, Eighth Ed., *Welding Processes*, ANSI/AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding* and ANSI/AWS A5.4, *Specification for Corrosion-Resisting Chromium and Chromium Nickel Steel Covered Electrodes*.
14. Keep training records reflecting results of shielded metal arc welding equipment set up, principles of operation and base/filler metal identification and selection.

LEARNING OBJECTIVE #5: Operate shielded metal arc welding equipment.

PERFORMANCE CONDITIONS: Provided with a period of instruction, and demonstration, protective clothing and equipment, shielded metal arc welding equipment accessories, E3XX-15/16, E6010 or E6011, and E7018 electrodes, hand tools, base metals or an assembly and a welding assignment, in the work area.

DESIRED BEHAVIOR: the trainee will perform shielded metal arc welding operations.

EVALUATION CRITERIA: The trainee's welding was completed as required by the welding assignment. During and after the operation, welds were visually examined by the trainee and accepted by the instructor. The objective is performed on a routine basis during the shielded metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the shielded metal arc welding principles of operation and common process variables elements from the related section of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to common process variables for shielded metal arc welding.
3. Provide training exercises related to shielded metal arc welding equipment operation.
4. Provide training exercises related to multi-pass groove welds in the 6G (multiple fixed position) on carbon steel or 300 series stainless steel pipe, using E3XX-15/16 electrodes.
5. Provide training exercises related to multi-pass groove welds in the 6GR (restricted, multiple fixed position) on carbon steel pipe, using E6010 or E6011 and E7018 electrodes.
6. Observe trainee following safe arc welding practices.
7. Observe trainee operating shielded metal arc welding equipment.
8. Visually inspect trainee's workmanship samples.
9. Develop and administer formative or diagnostic tests relevant to shielded metal arc welding principles of operation and common process variables.
10. Prepare trainee for the shielded metal arc welding principles of operation and common process variables portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*.
11. Keep training records reflecting results of shielded metal arc welding equipment principles of operation, common process variables and performance exercises.

LEARNING OBJECTIVE #6: Execute corrective action to repair surface flaws on welds and base metals.

PERFORMANCE CONDITIONS: Provided with a period of demonstration, protective clothing and equipment, shielded metal arc welding equipment and accessories, shop equipment or tools, prepared base metals or an assembly, and a welding assignment, in the work area.

DESIRED BEHAVIOR: the trainee will take corrective actions to repair surface flaws in welds or on base metals.

EVALUATION CRITERIA: The trainee's workmanship sample is free of base metal and weld metal surface flaws. The workmanship sample meets the design and welding specifications of the welding assignment. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced on an as-required basis during the length of the program.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the repair of surface flaws on the prepared edges and surfaces of base metals using the SMAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
2. Provide instruction related to the repair of visible surface flaws in weld metal using the SMAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
3. Provide demonstrations related to the repair of surface flaws on the prepared edges and surfaces of base metals using the SMAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
4. Provide demonstrations related to the repair of visible surface flaws in weld metal using the SMAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
5. Require the trainee to repair surface flaws on the prepared edges and surfaces of base metals.
6. Require the trainee to repair visible surface flaws in weld metal.
7. Require the trainee to notify the instructor of all repairs to surface flaws on the prepared edges and surfaces of base metals.
8. Require the trainee to notify the instructor of all repairs to visible surface flaws in weld metal.
9. Observe trainee making repairs.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to corrective actions for the repair of surface flaws in welds or base metal surfaces.
12. Keep training records reflecting the results of corrective actions for the repair of surface flaws in welds or base metal surfaces training.

LEARNING OBJECTIVE #7: Perform a 6GR unlimited thickness range performance qualification test on carbon steel pipe, without backing, using the shielded metal arc welding process.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, shielded metal arc welding equipment, accessories, E6010 or E6011, and E7018 electrodes, 12" Ø Schedule 80 carbon steel pipe, suitable restriction ring material, Welding Procedure Specification AWS3–SMAW–1, Drawing #AWS3–1 (figure 2), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6GR (multiple, restricted) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS3–SMAW–1 and Drawing #AWS3–1, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiography requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating shielded metal arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS3–SMAW–1 and Drawing #AWS3–1.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–1.

***Note:** **This Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #7 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.1.1 *SMAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform a duplicate performance qualification test for this learning objective.**

LEARNING OBJECTIVE #8: Perform a 6G limited thickness range performance qualification test on carbon steel or 300 series stainless steel pipe, with backing, using the shielded metal arc welding process and stainless steel electrodes.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, shielded metal arc welding equipment, accessories, E3XX-15/16 electrodes, 2 1/2" - 6"Ø Schedule 40 carbon steel or 40S stainless steel pipe, Welding Procedure Specification AWS2–1–SMAW or ANSI/AWS B2.1-8-023, Drawing #AWS3–2 (figure 3), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS2–1–SMAW or ANSI/AWS B2.1-8-023, and Drawing #AWS3–2, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating shielded metal arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS2–1–SMAW or ANSI/AWS B2.1-8-023, and Drawing #AWS3–2.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–2.

***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #8 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.1.2 *SMAW Performance Qualifications* of this guide.Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform a duplicate performance qualification test for this learning objective.**

3.3.6.3 UNIT #3: GAS METAL ARC WELDING (GMAW–S, GMAW)

LEARNING OBJECTIVE #1: Perform safety inspections of equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, safety inspection guidelines, protective clothing and equipment, hand tools, gas metal arc welding equipment and accessories, a single or mixed shielding gas supply with equipment and accessories, in the work area.

DESIRED BEHAVIOR: the trainee performs safety inspections of protective clothing and equipment, hand tools, gas metal arc welding equipment and accessories, shielding gas equipment and accessories, and the work area.

EVALUATION CRITERIA: The trainee's protective clothing and equipment, hand tools, gas metal arc welding equipment and accessories, shielding gas equipment and accessories, and work area meet safety requirements. Hazard warnings are communicated to others in the immediate area prior to the start of gas metal arc welding operations. In the course of daily operations the trainee is observed following safe practices. The objective is performed as required during the gas metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the arc welding safety element from the related sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide a safety tour and orientation for gas metal arc welding equipment and accessories, and shielding gas equipment and accessories.
3. Reinforce previous instruction from ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part I – General Aspects.
4. Provide instruction related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
5. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
6. Provide demonstrations related to routine safety inspections of protective equipment and clothing, gas metal arc welding equipment and accessories, shielding gas equipment and accessories, required tools and the work area.
7. Introduce related terms and definitions.
8. Observe trainee conducting safety inspections.
9. Observe trainee following safe practices.
10. Observe trainee using proper terms and definitions.
11. Develop and administer formative or diagnostic tests relevant to safe arc welding practices.
12. Prepare trainee for the arc welding safety portion of a closed book written examination from the related sections of ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*.
13. Keep records reflecting successful completion of GMAW safe practices training.

LEARNING OBJECTIVE #2: Make minor external repairs to gas metal arc welding equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and repair materials, equipment or tools, in the work area.

DESIRED BEHAVIOR: the trainee will make minor external repairs to gas metal arc welding equipment and accessories, and shielding gas equipment and accessories.

EVALUATION CRITERIA: Repairs to gas metal arc welding equipment and accessories, and shielding gas equipment and accessories are made in accordance with the manufacturer's recommendations and the institution's repair policy. The correct repair materials, equipment or tools are selected. The assignment is completed in a timely manner. The objective is performed as required during the gas metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas metal arc welding component identification element from the related sections of ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to gas metal arc welding component identification.
3. Provide instruction related to shielding gas equipment and accessory component identification.
4. Provide instruction related to minor external repairs to gas metal arc welding equipment and accessories.
5. Provide instruction related to minor external repairs to shielding gas equipment and accessories.
6. Provide demonstrations related to gas metal arc welding component identification
7. Provide demonstrations related to shielding gas equipment and accessory component identification.
8. Provide demonstrations related to minor external repairs on gas metal arc welding equipment and accessories.
9. Provide demonstrations related to minor external repairs on shielding gas equipment and accessories.
10. Introduce related terms and definitions.
11. Provide trainee with repair assignments when required.
12. Observe trainee following safe repair practices.
13. Observe trainee using proper terms and definitions.
14. Develop and administer formative or diagnostic tests relevant to gas metal arc welding, shielding gas equipment and accessory component identification.
15. Prepare trainee for the gas metal arc welding component identification portion of a closed book written examination from the related sections of ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*.
16. Keep training records reflecting results of gas metal arc welding, shielding gas equipment, and accessory component identification.

LEARNING OBJECTIVE #3: Set up components and accessories of a complete gas metal arc welding system.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, verbal or written instructions, protective clothing and equipment, gas metal arc welding equipment, accessories and hand tools in the work area.

DESIRED BEHAVIOR: the trainee will set up components and accessories of a complete gas metal arc weld.

EVALUATION CRITERIA: The gas metal arc welding system is operable. Verbal or written instructions are understood. All components and accessories of the system have been installed according to manufacturer's recommendations. The objective is performed as required during the gas metal arc welding portion of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction in component and accessory setup of a complete gas metal arc welding system.
3. Provide demonstrations of component and accessory setup of a complete gas metal arc welding system.
4. Provide training exercises for component and accessory setup of a complete gas metal arc welding system.
5. Observe trainee following safe practices.
6. Observe trainee setting up the components and accessories of a gas metal arc welding system.
7. Develop and administer formative or diagnostic tests relevant to component and accessory setup of a complete gas metal arc welding system.
8. Keep training records reflecting results of component and accessory setup of a complete gas metal arc welding system.

*Note: **This unit of instruction is designed to provide the trainee with a thorough understanding about GMAW system setup. This does not include the internal setup of the power source. This learning objective could be coupled with performance qualifications (the trainee sets up the system and then operates it as part of performance qualifications). This learning objective is also suited to tear down and setup. Have one trainee tear down the components and accessories and another set them back up.**

LEARNING OBJECTIVE #4: Set up for gas metal arc welding operations on aluminum and carbon steel.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas metal arc welding equipment and accessories, a mixed or single shielding gas supply with equipment and accessories, E4043, E70S–X electrodes, and base metal, in the work area.

DESIRED BEHAVIOR: the trainee will set up and prepare to perform gas metal arc welding operations on aluminum and carbon steel.

EVALUATION CRITERIA: The trainee is prepared to weld. Verbal or written instructions are understood. Protective clothing and equipment are suitable for job requirements. The proper hand tools, equipment, base metal, shielding gas, and filler metals are selected. Gas metal arc welding equipment is set up and adjusted to the proper voltage, wire feed speed, and polarity. Shielding gas equipment is set up and adjusted to the proper flow rate. Parts are assembled and preheated according to job requirements. The objective is performed on a routine basis during the gas metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas metal arc welding principles of operation, and filler metal identification/selection elements from the related sections of ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*, ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for Gas-shielded Arc Welding*, ANSI/AWS A5.10, *Specification for Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes and* ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting* of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction in gas metal arc welding principles of operation.
3. Provide instruction in shielding gases relevant to the gas metal arc welding process.
4. Provide instruction in gas metal arc welding filler metal identification and selection.
5. Provide demonstrations related to gas metal arc welding equipment and accessory set up.
6. Provide demonstrations related to shielding gas equipment and accessory set up.
7. Introduce related terms and definitions.
8. Provide trainee with practice setting up gas metal arc welding equipment and accessories.
9. Provide trainee with practice setting up shielding gas equipment and accessories.
10. Observe trainee following safe practices.
11. Observe trainee using proper terms and definitions.
12. Observe trainee setting up gas metal arc welding equipment and accessories.
13. Observe trainee setting up shielding gas equipment and accessories.
14. Develop and administer formative or diagnostic tests relevant to gas metal arc welding principles of operation, filler metal classification and selection.

(continued on the next page)

15. Prepare trainee for the gas metal arc welding principles of operation, and filler metal identification/selection portion of a closed book written examination from the related sections of ANSI/AWS C5.6 *Recommended Practices for Gas Metal Arc Welding*, ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for Gas-shielded Arc Welding*, ANSI/AWS A5.10, *Specification for Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes* and ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting*.
16. Keep training records reflecting results of gas metal arc welding equipment set up, principles of operation, and filler metal identification/selection.

LEARNING OBJECTIVE #5: Operate gas metal arc welding equipment.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas metal arc welding equipment and accessories, a 100% argon shielding gas with equipment and accessories, 3/64 or 1/16 E4043 or E5XXX, and .035 E70S–X electrodes, base metal, and a welding assignment, in the work area.

DESIRED BEHAVIOR: the trainee will perform short circuit and pulsed spray transfer gas metal arc welding operations.

EVALUATION CRITERIA: The trainee's welding was completed as required by the welding assignment. During and after the operation, welds are visually examined by the trainee and accepted by the instructor. The objective is performed on a routine basis during the gas metal arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas metal arc principles of operation and common process variables elements from the related section of ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to gas metal arc welding principles of operation.
3. Provide instruction related to common process variables for gas metal arc welding.
4. Provide demonstrations related to gas metal arc welding equipment operations.
5. Provide training exercises related to gas metal arc welding equipment operation.
6. Provide training exercises related to multiple pass, groove welds in the 6G position (multiple fixed position), on aluminum pipe, using pulsed spray transfer, 3/64 or 1/16 diameter E4043 or E5XXX electrodes and a 100% argon shielding gas.
7. Provide training exercises related to multiple pass, groove welds in the 6G position (multiple fixed position), on carbon steel pipe, using short circuiting transfer, .035 diameter E70S–X electrodes and a 75% argon/25% CO_2 shielding gas.
8. Observe trainee following safe arc welding practices.
9. Observe trainee operating gas metal arc welding equipment.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to gas metal arc welding principles of operation and common process variables.
12. Prepare trainee for the gas metal arc welding principles of operation and common process variables portion of a closed book written examination from the related sections of ANSI/AWS C5.6, *Recommended Practices for Gas Metal Arc Welding*.
13. Keep training records reflecting results of gas metal arc welding equipment principles of operation, common process variables and performance exercises.

LEARNING OBJECTIVE #6: Execute corrective action to repair surface flaws on welds and base metals.

PERFORMANCE CONDITIONS: Provided with a period of demonstration, protective clothing and equipment, gas metal arc welding equipment and accessories, shop equipment or tools, prepared base metals or an assembly, and a welding assignment, in the work area,

DESIRED BEHAVIOR: the trainee will take corrective actions to repair surface flaws in welds or on base metals.

EVALUATION CRITERIA: The trainee's workmanship sample is free of base metal and weld metal surface flaws. The workmanship sample meets the design and welding specifications of the welding assignment. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced on an as required basis during the length of the program.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the repair of surface flaws on the prepared edges and surfaces of base metals using the GMAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
2. Provide instruction related to the repair of visible surface flaws in weld metal using the GMAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
3. Provide demonstrations related to the repair of surface flaws on the prepared edges and surfaces of base metals using the GMAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
4. Provide demonstrations related to the repair of visible surface flaws in weld metal using the GMAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
5. Require the trainee to repair surface flaws on the prepared edges and surfaces of base metals.
6. Require the trainee to repair visible surface flaws in weld metal.
7. Require the trainee to notify the instructor of all repairs to surface flaws on the prepared edges and surfaces of base metals.
8. Require the trainee to notify the instructor of all repairs to visible surface flaws in weld metal.
9. Observe trainee making repairs.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to corrective actions for the repair of surface flaws in welds or base metal surfaces.
12. Keep training records reflecting the results of corrective actions for the repair of surface flaws in welds or base metal surfaces training.

LEARNING OBJECTIVE #7: Perform a 6G limited thickness range performance qualification test on carbon steel pipe using short circuiting transfer.

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, gas metal arc welding equipment and accessories, a 75% argon/25% CO2 shielding gas supply with equipment and accessories, .035 E70S–X electrodes, 2 1/2" - 6"Ø (optional dia.) Schedule 40 carbon steel pipe, Welding Procedure Specifications AWS2–2–GMAW, Drawing #AWS3–3 (figure 4), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS2–2–GMAW and Drawing #AWS3–3, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating gas metal arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS2–2–GMAW and Drawing #AWS3–3.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–3.

***Note: Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #7 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.2.1 *GMAW Performance Qualifications* of this guide.Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform a duplicate performance qualification test for this learning objective.**

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LEARNING OBJECTIVE #8: Perform a 6G limited thickness range performance qualification test on aluminum pipe using pulsed spray transfer.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, gas metal arc welding equipment and accessories, a 100 % argon shielding gas with equipment and accessories, 3/64 or 1/16 E4043 or E5XXX electrodes, 2 1/2" - 6"Ø (optional dia.) Schedule 40 aluminum pipe, Welding Procedure Specifications AWS3–GMAW-P–1 or AWS3–GMAW-P–2, Drawing #AWS3–4 (figure 5), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS3–GMAW-P–1 or AWS3–GMAW-P–2 and Drawing #AWS3–4, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating gas metal arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS3–GMAW-P–1 or AWS3–GMAW-P–2 and Drawing #AWS3–4.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–4.

***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #8 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.2.2 *GMAW Performance Qualifications* of this guide.Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform a duplicate performance qualification test for this learning objective.**

3.3.6.4 UNIT #4: FLUX CORED ARC WELDING (FCAW–S, FCAW–G)

LEARNING OBJECTIVE #1: Perform safety inspections of equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, safety inspection guidelines, protective clothing and equipment, hand tools, flux cored arc welding equipment and accessories, shielding gas supply with equipment and accessories, in the work area.

DESIRED BEHAVIOR: the trainee performs safety inspections of protective clothing and equipment, hand tools, flux cored arc welding equipment and accessories, shielding gas equipment and accessories, and the work area.

EVALUATION CRITERIA: The trainee's protective clothing and equipment, hand tools, flux cored arc welding equipment and accessories, shielding gas equipment and accessories, and work area meet safety requirements. Hazard warnings are communicated to others in the immediate area prior to the start of flux cored arc welding operations. In the course of daily operations the trainee is observed following safe practices. The objective is performed as required during the flux cored arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the arc welding safety element from the related sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide a safety tour and orientation for flux cored arc welding equipment and accessories, and shielding gas equipment and accessories.
3. Reinforce previous instruction from ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part I – General Aspects.
4. Provide instruction related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
5. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
6. Provide demonstrations related to routine safety inspections of protective equipment and clothing, flux cored arc welding equipment and accessories, shielding gas equipment and accessories, required tools and the work area.
7. Introduce related terms and definitions.
8. Observe trainee conducting safety inspections.
9. Observe trainee following safe practices.
10. Observe trainee using proper terms and definitions.
11. Develop and administer formative or diagnostic tests relevant to safe arc welding practices.
12. Prepare trainee for the arc welding safety portion of a closed book written examination from the related sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*.
13. Keep records reflecting successful completion of FCAW safe practices training.

LEARNING OBJECTIVE #2: Make minor external repairs to flux cored arc welding equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, and repair materials, equipment or tools, in the work area.

DESIRED BEHAVIOR: the trainee will make minor external repairs to flux cored arc welding equipment and accessories, and shielding gas equipment and accessories.

EVALUATION CRITERIA: The trainee's repairs to flux cored arc welding equipment and accessories, and shielding gas equipment and accessories are made in accordance with the manufacturer's recommendations and the institution's repair policy. The correct repair materials, equipment, or tools are selected. The assignment is completed in a timely manner. The objective is performed as required during the flux cored arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the flux cored arc welding component identification element from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to flux cored arc welding component identification.
3. Provide instruction related to shielding gas equipment and accessory component identification.
4. Provide instruction related to minor external repairs to flux cored arc welding equipment and accessories.
5. Provide instruction related to minor external repairs to shielding gas equipment and accessories.
6. Provide demonstrations related to flux cored arc welding component identification.
7. Provide demonstrations related to shielding gas equipment and accessory component identification.
8. Provide demonstrations related to minor external repairs on flux cored arc welding equipment and accessories.
9. Provide demonstrations related to minor external repairs on shielding gas equipment and accessories.
10. Introduce related terms and definitions.
11. Provide trainee with repair assignments when required.
12. Observe trainee following safe repair practices.
13. Observe trainee using proper terms and definitions.
14. Develop and administer formative or diagnostic tests relevant to flux cored arc welding, shielding gas equipment, and accessory component identification.
15. Prepare trainee for the flux cored arc welding component identification portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*.
16. Keep training records reflecting results of flux cored arc welding, shielding gas equipment and accessory component identification.

LEARNING OBJECTIVE #3: Set up components and accessories of a complete flux cored arc welding system.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, verbal or written instructions, protective clothing and equipment, flux cored arc welding equipment, accessories and hand tools in the work area.

DESIRED BEHAVIOR: the trainee will set up components and accessories of a complete flux cored arc welding system.

EVALUATION CRITERIA: The flux cored arc welding system is operable. Verbal or written instructions are understood. All components and accessories of the system have been installed according to manufacturer's recommendations. The objective is performed as required during the flux cored arc welding portion of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction in component and accessory setup of a complete flux cored arc welding system.
3. Provide demonstrations of component and accessory setup of a complete flux cored arc welding system.
4. Provide training exercises for component and accessory setup of a complete flux cored arc welding system.
5. Observe trainee following safe practices.
6. Observe trainee setting up the components and accessories of a flux cored arc welding system.
7. Develop and administer formative or diagnostic tests relevant to component and accessory setup of a complete flux cored arc welding system.
8. Keep training records reflecting results of component and accessory setup of a complete flux cored arc welding system.

*Note: **This unit of instruction is designed to provide the trainee with a thorough understanding about FCAW system setup. This does not include the internal setup of the power source. This learning objective could be coupled with performance qualifications (the trainee sets up the system and then operates it as part of performance qualifications). This learning object is also suited to tear down and setup. Have one trainee tear down the components and accessories and another set them back up.**

LEARNING OBJECTIVE #4: Set up for flux cored arc welding operations on carbon steel.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, flux cored arc welding equipment and accessories, a mixed or single shielding gas supply (when required) with equipment and accessories, E71T–1 or E71T–11 electrodes, and base metals, in the work area.

DESIRED BEHAVIOR: the trainee will set up and prepare to perform self-shielded and gas-shielded flux cored arc welding operations on carbon steel.

EVALUATION CRITERIA: The trainee is prepared to weld. Verbal or written instructions are understood. Protective clothing and equipment are suitable for job requirements. The proper hand tools, equipment, base metal, shielding gas, and filler metals are selected. Flux cored arc welding equipment is set up and adjusted to the proper voltage, wire feed speed, and polarity. Shielding gas equipment is set up and adjusted to the proper flow rate. Parts are assembled and preheated according to job requirements. The objective is performed on a routine basis during the flux cored arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the flux cored arc welding principles of operation, and filler metal identification/selection elements from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*, ANSI/AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding* and ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting* of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction in flux cored arc welding principles of operation.
3. Provide instruction in shielding gases for gas-shielded flux cored arc welding.
4. Provide instruction in the flux cored arc welding filler metal identification and selection.
5. Provide demonstrations related to flux cored arc welding equipment and accessory set up.
6. Provide demonstrations related to shielding gas equipment and accessory set up.
7. Introduce related terms and definitions.
8. Provide trainee with practice setting up flux cored arc welding equipment and accessories.
9. Provide trainee with practice setting up shielding gas equipment and accessories.
10. Observe trainee following safe practices.
11. Observe trainee using proper terms and definitions.
12. Observe trainee setting up flux cored arc welding equipment and accessories.
13. Observe trainee setting up shielding gas equipment and accessories.
14. Develop and administer formative or diagnostic tests relevant to flux cored arc welding principles of operation and filler metal identification and selection.
15. Prepare trainee for the flux cored arc welding principles of operation, and filler metal identification/selection portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*, ANSI/AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding* and ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting*.
16. Keep training records reflecting results of flux cored arc welding equipment set up, principles of operation, and filler metal identification/selection.

LEARNING OBJECTIVE #5: Operate flux cored arc welding equipment.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, flux cored arc welding equipment and accessories, 75% argon/25% CO_2 shielding gas with equipment and accessories (when required), 1/16 diameter E71T–1 (gas-shielded) and E71T–11 (self-shielded) electrodes, base metals, and a welding assignment, in the work area,

DESIRED BEHAVIOR: the trainee will perform self-shielded and gas-shielded flux cored arc welding operations.

EVALUATION CRITERIA: The trainee's welding was completed as required by the welding assignment. During and after the operation, welds are visually examined by the trainee and accepted by the instructor. The objective is performed on a routine basis during the flux cored arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the flux cored arc welding principles of operation and common process variables elements from the related section of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to flux cored arc welding principles of operation.
3. Provide instruction related to common process variables for flux cored arc welding.
4. Provide demonstrations related to flux cored arc welding equipment operations.
5. Provide training exercises related to multiple pass, groove welds in the 6G position (multiple fixed position), on carbon steel pipe, using 1/16 diameter E71T–11 (self-shielded) electrode.
6. Provide training exercises related to multiple pass, groove welds in the 6G position (multiple fixed position), on carbon steel pipe, using 1/16 diameter E71T–1 (gas-shielded) electrodes, and 75% argon/25% CO_2 shielding gas.
7. Observe trainee following safe arc welding practices.
8. Observe trainee operating flux cored arc welding equipment.
9. Visually inspect trainee's workmanship samples.
10. Develop and administer formative or diagnostic tests relevant to flux cored arc welding principles of operation and common process variables.
11. Prepare trainee for the flux cored arc welding principles of operation and common process variables portion of a closed book written examination from the related sections of AWS Welding Handbook, Volume 2, Eighth Ed., *Welding Processes*.
12. Keep training records reflecting results of flux cored arc welding equipment principles of operation, common process variables and performance exercises.

LEARNING OBJECTIVE #6: Execute corrective action to repair surface flaws on welds and base metals.

PERFORMANCE CONDITIONS: Provided with a period of demonstration, protective clothing and equipment, flux cored arc welding equipment and accessories, shop equipment or tools, prepared base metals or an assembly, and a welding assignment, in the work area,

DESIRED BEHAVIOR: the trainee will take corrective actions to repair surface flaws in welds or on base metals.

EVALUATION CRITERIA: The trainee's workmanship sample is free of base metal and weld metal surface flaws. The workmanship sample meets the design and welding specifications of the welding assignment. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced on an as-required basis during the length of the program.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the repair of surface flaws on the prepared edges and surfaces of base metals using the FCAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
2. Provide instruction related to the repair of visible surface flaws in weld metal using the FCAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
3. Provide demonstrations related to the repair of surface flaws on the prepared edges and surfaces of base metals using the FCAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
4. Provide demonstrations related to the repair of visible surface flaws in weld metal using the FCAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
5. Require the trainee to repair surface flaws on the prepared edges and surfaces of base metals.
6. Require the trainee to repair visible surface flaws in weld metal.
7. Require the trainee to notify the instructor of all repairs to surface flaws on the prepared edges and surfaces of base metals.
8. Require the trainee to notify the instructor of all repairs to visible surface flaws in weld metal.
9. Observe trainee making repairs.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to corrective actions for the repair of surface flaws in welds or base metal surfaces.
12. Keep training records reflecting the results of corrective actions for the repair of surface flaws in welds or base metal surfaces training.

LEARNING OBJECTIVE #7: Perform a 6G limited thickness range performance qualification test on carbon steel pipe using self-shielded electrodes.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, flux cored arc welding equipment and accessories, 1/16 diameter E71T–11 (self-shielded) electrode, 2 1/2" - 6"Ø (optional dia.) Schedule 40 carbon steel pipe, Welding Procedure Specification ANSI/AWS B2.1-027, Drawing #AWS3–5 (figure 6), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-027 and Drawing #AWS3–5, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating flux cored arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-027 and Drawing #AWS3–5.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–5.

***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #7 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.3.1 *FCAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform the performance qualification test for this learning objective.**

LEARNING OBJECTIVE #8: Perform a 6G limited thickness range performance qualification test on carbon steel pipe using gas-shielded electrodes.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, flux cored arc welding equipment and accessories, a 75% argon/25% CO_2 shielding gas supply with equipment and accessories, 1/16 diameter E71T–1 (gas-shielded) electrode, 2 1/2" - 6"Ø (optional dia.) Schedule 40 carbon steel pipe, Welding Procedure Specification ANSI/AWS B2.1-020, Drawing #AWS3–5 (figure 6), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-020 and Drawing #AWS3–5, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
3. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
4. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating flux cored arc welding equipment.
7. Visually inspect and bend test the trainee's workmanship sample.
8. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
9. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-020 and Drawing #AWS3–5.
10. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–5.

***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #8 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.3.2 *FCAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform the performance qualification test for this learning objective.**

3.3.6.5 UNIT #5: GAS TUNGSTEN ARC WELDING (GTAW)

LEARNING OBJECTIVE #1: Perform safety inspections of equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, safety inspection guidelines, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, a shielding gas supply with equipment and accessories, in the work area.

DESIRED BEHAVIOR: the trainee performs safety inspections of protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, shielding gas equipment and accessories, and the work area.

EVALUATION CRITERIA: The trainee's protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, shielding gas equipment and accessories, and work area meet safety requirements. Hazard warnings are communicated to others in the immediate area prior to the start of gas tungsten arc welding operations. In the course of daily operations the trainee is observed following safe practices. The objective is performed as required during the gas tungsten arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the arc welding safety portion element from the related sections of ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide a safety tour and orientation for gas tungsten arc welding equipment and accessories, and shielding gas equipment and accessories.
3. Reinforce previous instruction from ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part I – General Aspects.
4. Provide instruction related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
5. Provide demonstrations related to ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II – Specific Processes, 11. Arc Welding and Cutting Equipment Safety.
6. Provide demonstrations related to routine safety inspections of protective equipment and clothing, gas tungsten arc welding equipment and accessories, shielding gas equipment and accessories, required tools and the work area.
7. Introduce related terms and definitions.
8. Observe trainee conducting safety inspections.
9. Observe trainee following safe practices.
10. Observe trainee using proper terms and definitions.
11. Develop and administer formative or diagnostic tests relevant to safe arc welding practices.
12. Prepare trainee for the arc welding safety portion of a closed book written examination from the related sections of ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*.
13. Keep records reflecting successful completion of GTAW safe practices training.

LEARNING OBJECTIVE #2: Make minor external repairs to gas tungsten arc welding equipment and accessories.

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, and repair materials, equipment or tools, in the work area.

DESIRED BEHAVIOR: the trainee will make minor external repairs to gas tungsten arc welding equipment and accessories, and shielding gas equipment and accessories.

EVALUATION CRITERIA: The trainee's repairs to gas tungsten arc welding equipment and accessories, and shielding gas equipment and accessories are made in accordance with the manufacturer's recommendations and the institution's repair policy. The correct repair materials, equipment or tools are selected. The assignment is completed in a timely manner. The objective is performed as required during the gas tungsten arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas tungsten arc welding component identification element from the related sections of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding* and AWS Welding Handbook, Vol. 1, Eighth Ed., *Welding Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to gas tungsten arc welding component identification.
3. Provide instruction related to shielding gas equipment and accessory component identification.
4. Provide instruction related to minor external repairs to gas tungsten arc welding equipment and accessories.
5. Provide instruction related to minor external repairs to shielding gas equipment and accessories.
6. Provide demonstrations related to gas tungsten arc welding component identification.
7. Provide demonstrations related to shielding gas equipment and accessory component identification.
8. Provide demonstrations related to minor external repairs on gas tungsten arc welding equipment and accessories.
9. Provide demonstrations related to minor external repairs on shielding gas equipment and accessories.
10. Introduce related terms and definitions
11. Provide trainee with repair assignments when required.
12. Observe trainee following safe repair practices.
13. Observe trainee using proper terms and definitions.
14. Develop and administer formative or diagnostic tests relevant to gas tungsten arc welding shielding gas equipment, and accessory component identification.
15. Prepare trainee for the gas tungsten arc welding component identification portion of a closed book written examination from the related sections of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding* and AWS Welding Handbook, Vol. 2, Eighth Ed., *Welding Processes*.
16. Keep training records reflecting results of gas tungsten arc welding, shielding gas equipment and accessory component identification.

LEARNING OBJECTIVE #3: Set up components and accessories of a complete gas tungsten arc welding system.*

PERFORMANCE CONDITIONS: Provided with a period of instruction, demonstration, verbal or written instructions, protective clothing and equipment, gas tungsten arc welding equipment, accessories and hand tools in the work area.

DESIRED BEHAVIOR: the trainee will set up components and accessories of a complete gas tungsten arc welding system.

EVALUATION CRITERIA: The gas tungsten arc welding system is operable. Verbal or written instructions are understood. All components and accessories of the system have been installed according to manufacturer's recommendations. The objective is performed as required during the gas tungsten arc welding portion of the program. The trainee's knowledge is tested according to the summative evaluation criteria of the training facility.

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the documents specified for this learning objective.
2. Provide instruction in component and accessory setup of a complete gas tungsten arc welding system.
3. Provide demonstrations of component and accessory setup of a complete gas tungsten arc welding system.
4. Provide training exercises for component and accessory setup of a complete gas tungsten arc welding system.
5. Observe trainee following safe practices.
6. Observe trainee setting up the components and accessories of a gas tungsten arc welding system.
7. Develop and administer formative or diagnostic tests relevant to component and accessory setup of a complete gas tungsten arc welding system.
8. Keep training records reflecting results of component and accessory setup of a complete gas tungsten arc welding system.

*Note: **This unit of instruction is designed to provide the trainee with a thorough understanding about GTAW system setup. This does not include the internal setup of the power source. This learning objective could be coupled with performance qualifications (the trainee sets up the system and then operates it as part of performance qualifications). This learning objective is also suited to tear down and setup. Have one trainee tear down the components and accessories and another set them back up.**

LEARNING OBJECTIVE #4: Set up for gas tungsten arc welding operations on carbon steel, stainless steel, aluminum and nickel, copper, magnesium and/or titanium alloys.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, argon shielding gas supply with equipment and accessories, ER70S–X (carbon steel), ER3XX (stainless steel), ER4043 or ER5XXX (aluminum), ERNi (or suitable nickel alloy) ERCu (or suitable copper alloy), ER AZXX (or suitable magnesium alloy) and/or ERTi-X (suitable titanium) filler metals, appropriate tungsten electrodes, and base metals, in the work area.

DESIRED BEHAVIOR: the trainee will set up and prepare to perform gas tungsten arc welding operations on carbon steel, stainless steel, aluminum and copper alloy, nickel alloy, magnesium and/or titanium alloys.

EVALUATION CRITERIA: The trainee is prepared to weld. Verbal or written instructions are understood. Protective clothing and equipment are suitable for job requirements. The proper hand tools, equipment, base metal, shielding gas, and filler metals are selected. Gas tungsten arc welding equipment is set up and adjusted to the proper current and polarity. Shielding gas equipment is set up and adjusted to the proper flow rate. Parts are assembled and preheated according to job requirements. The objective is performed on a routine basis during the gas tungsten arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas tungsten arc welding principles of operation, tungsten electrode, base/filler metal identification/selection gas shielding identification/selection elements from the related sections of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding*, AWS Welding Handbook, Vol. 2, Eighth Ed., *Welding Processes*, ANSI/AWS A5.7, *Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes*, ANSI/AWS A5.9, *Specification for Bare Stainless Steel Welding Electrodes and Rods*, ANSI/AWS A5.10, *Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods*, ANSI/AWS A5.12, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*, ANSI/AWS A5.14, *Specification for Nickel and Nickel Alloy Welding Electrodes and Rods*, ANSI/AWS A5.16, *Specification for Titanium and Titanium Alloy Welding Electrodes and Rods*, ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for Gas-shielded Arc Welding*, ANSI/AWS A5.19, *Specification for Magnesium and Magnesium Alloy Welding Electrodes and Rods*, ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting* and AWS Welding Handbook, Volume 1, Eighth Ed., *Welding Technology*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction in gas tungsten arc welding principles of operation.
3. Provide instruction in shielding gases as related to the gas tungsten arc welding process.
4. Provide instruction in carbon steel, stainless steel, aluminum and copper alloy, nickel alloy, magnesium and/or titanium alloys identification/selection.
5. Provide instruction in tungsten electrode identification/selection for carbon steel, stainless steel, aluminum and copper alloy, nickel alloy, magnesium and/or titanium alloys.

6. Provide instruction in the gas tungsten arc welding filler metal identification/selection for carbon steel, stainless steel, aluminum and copper alloy, nickel alloy, magnesium and/or titanium alloys.
7. Provide demonstrations related to gas tungsten arc welding equipment and accessory set up.
8. Provide demonstrations related to shielding gas equipment and accessory set up.
9. Introduce related terms and definitions.
10. Provide trainee with practice setting up gas tungsten arc welding equipment and accessories.
11. Provide trainee with practice setting up shielding gas equipment and accessories.
12. Observe trainee following safe practices.
13. Observe trainee using proper terms and definitions.
14. Observe trainee setting up gas tungsten arc welding equipment and accessories.
15. Observe trainee setting up shielding gas equipment and accessories.
16. Develop and administer formative or diagnostic tests relevant to gas tungsten arc welding principles of operation, tungsten electrode identification/selection, and base/filler metal identification/selection.
17. Prepare trainee for the gas tungsten arc welding principles of operation, carbon steel, stainless steel, aluminum and copper alloy, nickel alloy, magnesium and/or titanium alloys weldability, and filler metal classification portion of a closed book written examination from the related sections of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding*, AWS Welding Handbook, Vol. 2, Eighth Ed., *Welding Processes*, ANSI/AWS A5.7, *Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes*, ANSI/AWS A5.9, *Specification for Bare Stainless Steel Welding Electrodes and Rods*, ANSI/AWS A5.10, *Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods*, ANSI/AWS A5.12, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*, ANSI/AWS A5.14, *Specification for Nickel and Nickel Alloy Welding Electrodes and Rods*, ANSI/AWS A5.16, *Specification for Titanium and Titanium Alloy Welding Electrodes and Rods*, ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for Gas-shielded Arc Welding*, ANSI/AWS A5.19, *Specification for Magnesium and Magnesium Alloy Welding Electrodes and Rods*, ANSI/AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting* and AWS Welding Handbook, Volume 1, Eighth Ed., *Welding Technology*
18. Keep training records reflecting results of gas tungsten arc welding equipment set up, principles of operation, tungsten electrode identification/selection, and base/filler metal identification/selection.

LEARNING OBJECTIVE #5: Operate gas tungsten arc welding equipment.

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ER70S–X (carbon steel), ER3XX (stainless steel), ER4043 or ER5XXX (aluminum) and ERCu (or suitable copper alloy), ERNi (or suitable nickel alloy), ER AZXX (or suitable magnesium alloy) and/or ERTi-X (suitable titanium alloy) filler metals, appropriate tungsten electrodes, and base metals, in the work area.

DESIRED BEHAVIOR: the trainee will perform gas tungsten arc welding operations.

EVALUATION CRITERIA: The trainee's welding was completed as required by the welding assignment. During and after the operation, welds were visually examined by the trainee and accepted by the instructor. The objective is performed on a routine basis during the gas tungsten arc welding portion of the program. In accordance with the requirements of AWS QC12, the trainee shall pass the gas tungsten arc welding principles of operation and common process variables element from the related section of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding* and AWS Welding Handbook, Vol. 2, Eighth Ed., *Welding Processes*, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Ensure that existing or new training materials are in compliance with the AWS documents specified for this learning objective.
2. Provide instruction related to gas tungsten arc welding principles of operation.
3. Provide instruction related to common process variables for gas tungsten arc welding.
4. Provide demonstrations related to gas tungsten arc welding equipment operations.
5. Provide training exercises related to gas tungsten arc welding equipment operation.
6. Provide training exercises related to multi-pass groove welds in the 6G (multiple fixed position) on carbon steel, stainless steel and aluminum round tubing or pipe, using applicable filler metals, tungsten electrode, and shielding gas.
7. Provide training exercises related to a single 1F fillet weld, on copper, nickel and magnesium and/or titanium alloys, using applicable filler metals, tungsten electrode, and shielding gas.
8. Observe trainee following safe arc welding practices.
9. Observe trainee operating gas tungsten arc welding equipment.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to gas tungsten arc welding principles of operation and common process variables.
12. Prepare trainee for the gas tungsten arc welding principles of operation and common process variables portion of a closed book written examination from the related sections of ANSI/AWS C5.5, *Recommended Practices for Gas Tungsten Arc Welding* and AWS Welding Handbook, Vol. 2, Eighth Ed., *Welding Processes*.
13. Keep training records reflecting results of gas tungsten arc welding equipment principles of operation, common process variables, and performance exercises.

LEARNING OBJECTIVE #6: Execute corrective action to repair surface flaws on welds and base metals.

PERFORMANCE CONDITIONS: Provided with a period of demonstration, protective clothing and equipment, gas tungsten arc welding equipment and accessories, shop equipment or tools, prepared base metals or an assembly, and a welding assignment, in the work area.

DESIRED BEHAVIOR: the trainee will take corrective actions to repair surface flaws in welds or on base metals.

EVALUATION CRITERIA: The trainee's workmanship sample is free of base metal and weld metal surface flaws. The workmanship sample meets the design and welding specifications of the welding assignment. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced on an as-required basis during the length of the program.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the repair of surface flaws on the prepared edges and surfaces of base metals using the GTAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
2. Provide instruction related to the repair of visible surface flaws in weld metal using the GTAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
3. Provide demonstrations related to the repair of surface flaws on the prepared edges and surfaces of base metals using the GTAW process and appropriate shop equipment or tools. (e.g. correction to thickness caused by excessive grinding, or gouges in oxyfuel and arc cut edges or surfaces)
4. Provide demonstrations related to the repair of visible surface flaws in weld metal using the GTAW process and appropriate shop equipment or tools. (e.g. correction of weld size, slag, undercut, porosity, surface cracks, underfill, overlap, etc.)
5. Require the trainee to repair surface flaws on the prepared edges and surfaces of base metals.
6. Require the trainee to repair visible surface flaws in weld metal.
7. Require the trainee to notify the instructor of all repairs to surface flaws on the prepared edges and surfaces of base metals.
8. Require the trainee to notify the instructor of all repairs to visible surface flaws in weld metal.
9. Observe trainee making repairs.
10. Visually inspect trainee's workmanship samples.
11. Develop and administer formative or diagnostic tests relevant to corrective actions for the repair of surface flaws in welds or base metal surfaces.
12. Keep training records reflecting the results of corrective actions for the repair of surface flaws in welds or base metal surfaces training.

LEARNING OBJECTIVE #7: Make 2F and 1 G fillet and groove welds, on nickel alloys.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ERNi (or suitable nickel alloy) filler metals, EWP or EWZr tungsten electrodes, and base metals, in the work area,

DESIRED BEHAVIOR: the trainee will make fillet weld and groove welds on a nickel alloy in the 2F (horizontal) and 1G (flat) positions using the gas tungsten arc welding process.

EVALUATION CRITERIA: The trainee produces a sound fillet and groove weld in the 2F (horizontal) and 1G (flat) positions. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced for familiarization training only. In accordance with the requirements of AWS QC12, the trainee shall pass the GTAW weldability element from the applicable section of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 4, *Nickel and Cobalt Alloys*, Arc Welding, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the weldability of nickel alloys using the gas tungsten arc welding process from the related section of AWS Welding Handbook, Vol. 3, Eighth Ed., Chapter 4, *Nickel and Cobalt Alloys*, Arc Welding.
2. Provide instruction related to visual examination and repair of fillet and groove welds on nickel alloys produced with the gas tungsten arc welding process.
3. Provide demonstrations related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a nickel alloy, using an argon shielding gas supply, ERNi (or suitable nickel alloy) filler metals and an EWP or EWTh-2 tungsten electrode.
4. Provide training exercises related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a nickel alloy, using an argon shielding gas supply, ERNi (or suitable nickel alloy) filler metals and an EWP or EWTh-2 tungsten electrode.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating gas tungsten arc welding equipment.
7. Observe trainee taking corrective actions to repair surface flaws in base or weld metal.
8. Visually inspect trainee's workmanship samples.
9. Develop and administer formative or diagnostic tests relevant to nickel alloy weldability training.
10. Prepare trainee for the GTAW weldability element from the applicable section of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 4, *Nickel and Cobalt Alloys*, Arc Welding, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
11. Keep training records reflecting results of nickel alloy weldability training.

***Note:** **This unit of instruction is designed to reinforce previous nonferrous weldability training by allowing the student to recognize the relationship of theory to application. Any usable piece of nickel alloy material may be used for this exercise. The purpose of this training exercise is to demonstrate the sluggish flow of molten weld metal during welding.**

LEARNING OBJECTIVE #8: Make 2F and 1 G fillet and groove welds, on copper alloys.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, a helium or argon shielding gas supply with equipment and accessories, ERCu (or suitable copper alloy) filler metals, EWTh-1 or 2 tungsten electrodes, and base metals, in the work area.

DESIRED BEHAVIOR: the trainee will make fillet weld and groove welds on a copper alloy in the 2F (horizontal) and 1G (flat) positions using the gas tungsten arc welding process.

EVALUATION CRITERIA: The trainee produces a sound fillet and groove weld in the 2F (horizontal) and 1G (flat) positions. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced for familiarization training only. In accordance with the requirements of AWS QC12, the trainee shall pass the GTAW weldability element from the applicable section of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 3, *Copper and Copper Alloys*, Arc Welding, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the weldability of copper alloys using the gas tungsten arc welding process from the related section of AWS Welding Handbook, Vol. 3, Eighth Ed., Chapter 3, *Copper and Copper Alloys*, Arc Welding.
2. Provide instruction related to visual examination and repair of fillet and groove welds on copper alloys produced with the gas tungsten arc welding process.
3. Provide demonstrations related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a copper alloy, using a helium or argon shielding gas supply, ERCu (or suitable copper alloy) filler metals, and an EWTh-1 or 2 tungsten electrode.
4. Provide training exercises related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a copper alloy, using a helium or argon shielding gas supply, ERCu (or suitable copper alloy) filler metals, and an EWTh-1 or 2 tungsten electrode.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating gas tungsten arc welding equipment.
7. Observe trainee taking corrective actions to repair surface flaws in base or weld metal.
8. Visually inspect trainee's workmanship samples.
9. Develop and administer formative or diagnostic tests relevant to copper alloy weldability training.
10. Prepare trainee for the GTAW weldability element from the applicable section of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 3, *Copper and Copper Alloys*, Arc Welding, of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
11. Keep training records reflecting results of copper alloy weldability training.

***Note:** **This unit of instruction is designed to reinforce previous nonferrous weldability training by allowing the student to recognize the relationship of theory to application. Any usable piece of copper alloy material may be used for this exercise. The purpose of this training exercise is to demonstrate high heat input.**

LEARNING OBJECTIVE #9: Make 2F and 1 G fillet and groove welds, on magnesium and/or titanium alloys.*

PERFORMANCE CONDITIONS: Provided with a period of instruction and demonstration, verbal or written instructions, protective clothing and equipment, hand tools, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ER AZXX (or suitable magnesium alloy) and/or ERTi-X (suitable titanium alloy) filler metals, EWP, EWTh-1 or 2 or EWZr tungsten electrodes, and base metals, in the work area.

DESIRED BEHAVIOR: the trainee will make fillet weld and groove welds on a magnesium and/or titanium alloy in the 2F (horizontal) and 1G (flat) positions using the gas tungsten arc welding process.

EVALUATION CRITERIA: The trainee produces a sound fillet and groove weld in the 2F (horizontal) and 1G (flat) positions. During and after each welding operation, welds are visually examined by the welder and corrective actions taken to repair unfavorable conditions. The trainee reports corrective actions to the instructor. The completed assignment is visually examined and accepted by the instructor. The objective is practiced for familiarization training only. In accordance with the requirements of AWS QC12, the trainee shall pass the GTAW weldability element from the applicable section of AWS Welding Handbook, Volume 3, Eighth Ed., Chapter 2, *Magnesium and Magnesium Alloys*, Arc Welding, and AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys (titanium alloys), of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction related to the weldability of magnesium and/or titanium alloys using the gas tungsten arc welding process from the related section of AWS Welding Handbook, Vol. 3, Eighth Ed., Chapter 2, *Magnesium and Magnesium Alloys*, Arc Welding and AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys (titanium alloys).
2. Provide instruction related to visual examination and repair of fillet and groove welds on magnesium and/or titanium alloys produced with the gas tungsten arc welding process.
3. Provide demonstrations related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a magnesium and/or titanium alloy, using an argon shielding gas supply, ER AZXX (or suitable magnesium alloy) and/or ERTi-X (suitable titanium alloy) filler metals, and an EWP, EWTh-1 or 2 or EWZr tungsten electrode.
4. Provide training exercises related to 2F (horizontal) and 1G (flat) position fillet and groove welding on a magnesium and/or titanium alloy, using an argon shielding gas supply, ER AZXX (or suitable magnesium alloy) and/or ERTi-X (suitable titanium alloy) filler metals, and an EWP, EWTh-1 or 2 or EWZr tungsten electrode.
5. Observe trainee following safe arc welding practices.
6. Observe trainee operating gas tungsten arc welding equipment.
7. Observe trainee taking corrective actions to repair surface flaws in base or weld metal.
8. Visually inspect trainee's workmanship samples.

9. Develop and administer formative or diagnostic tests relevant to magnesium and/or titanium alloy weldability training.
10. Prepare trainee for the GTAW weldability element from the applicable section of AWS Welding Handbook, Vol. 3, Eighth Ed., Chapter 2, *Magnesium and Magnesium Alloys*, Arc Welding and AWS Welding Handbook, Volume 1, Eighth Ed., Chapter 4, *Welding Metallurgy*, Weldability of Commercial Alloys (titanium alloys), of Part A - Welding Fundamentals and Safety, a closed book written examination [summative testing].
11. Keep training records reflecting results of magnesium and titanium alloy weldability training.

***Note:** **This unit of instruction is designed to reinforce previous nonferrous weldability training by allowing the student to recognize the relationship of theory to application. Any usable piece of magnesium and/or titanium alloy material may be used for this exercise (alloy choice is optional). The purpose of this training exercise is to show the relationship of shielding to weld embrittlement.**

LEARNING OBJECTIVE #10: Perform a 6G limited thickness range performance qualification test on carbon steel round tubing or pipe.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ER70S–X (carbon steel) filler metals, EWTh–2 or EWCe–2 tungsten electrodes, 2 1/2"Ø carbon steel round tubing or pipe, Welding Procedure Specification ANSI/AWS B2.1-008, Drawing #AWS3–6 (figure 7), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-008, Drawing #AWS3–6, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction related to procedures for root shielding using the GTAW process.
3. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
4. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
5. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
6. Observe trainee following safe arc welding practices.
7. Observe trainee operating gas tungsten arc welding equipment.
8. Visually inspect and bend test the trainee's workmanship sample.
9. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
10. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-008, Drawing #AWS3–6.
11. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–6.

*Note: **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #10 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.4.1 *GTAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform the performance qualification test for this learning objective.**

LEARNING OBJECTIVE #11: Perform two 6G limited thickness range performance qualification tests one with consumable insert, one without, on carbon steel or stainless steel round tubing or pipe.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ER3XX (stainless steel) filler metals, EWTh–X, EWCe–X, EWZr or EWP tungsten electrodes, 2 1/2"Ø carbon steel or stainless steel round tubing or pipe, with and without a consumable insert, Welding Procedure Specification AWS3–GTAW–1, AWS3–GTAW–2, ANSI/AWS B2.1-009 or ANSI/AWS B2.1-010, Drawing #AWS3–6 (figure 7), and shop equipment or tools, in the work area, with no assistance from the instructor.

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position with and without a consumable insert. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS3–GTAW–1, AWS3–GTAW–2, ANSI/AWS B2.1-009 or ANSI/AWS B2.1-010, Drawing #AWS3–6, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction related to the use of consumable inserts from the applicable sections of ANSI/AWS A5.30, *Specification for Consumable Inserts* and procedures for root shielding using the GTAW process.
3. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
4. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
5. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
6. Observe trainee following safe arc welding practices.
7. Observe trainee operating gas tungsten arc welding equipment.
8. Visually inspect and bend test the trainee's workmanship sample.
9. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
10. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS3–GTAW–1 or AWS3–GTAW–2 and Drawing #AWS3–6. (with consumable insert)
11. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS ANSI/AWS B2.1-009 or ANSI/AWS B2.1-010 and Drawing #AWS3–6. (without insert)
12. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–6.

***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #11 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.4.2 *GTAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform the performance qualification test for this learning objective.**

LEARNING OBJECTIVE #12: Perform a 6G limited thickness range performance qualification test on aluminum round tubing or pipe.*

PERFORMANCE CONDITIONS: Provided with protective clothing and equipment, gas tungsten arc welding equipment and accessories, an argon shielding gas supply with equipment and accessories, ER4043 or ER5XXX (aluminum) filler metals, EWTh–X, EWZr or EWP tungsten electrodes, 2 1/2"Ø aluminum round tubing or pipe, Welding Procedure Specification AWS2-1-GTAW or AWS2-1.1-GTAW, Drawing #AWS3–6 (figure 7), and shop equipment or tools, in the work area, with no assistance from the instructor,

DESIRED BEHAVIOR: the trainee will perform welder performance qualification testing.

EVALUATION CRITERIA: The trainee produces sound groove welds in the 6G (multiple) position. Test assemblies are prepared according to drawing specifications and approved by the test supervisor. In accordance with the requirements of AWS QC12, WPS AWS2-1-GTAW or AWS2-1.1-GTAW, Drawing #AWS3–6, the trainee shall pass the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.

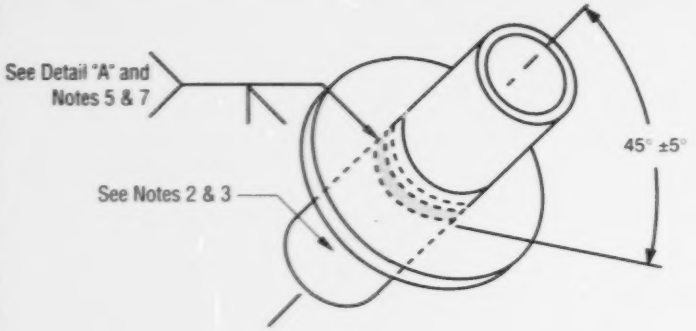
LEARNING ACTIVITIES:

The instructor shall:

1. Provide instruction in welding procedure and performance qualification related to this learning objective.
2. Provide instruction related to procedures for root shielding using the GTAW process.
3. Provide instruction in visual examination and bend testing or radiographic requirements for performance qualification related to this learning objective.
4. Provide demonstrations of fabrication and welding the performance qualification test weldment related to this learning activity.
5. Provide training exercises for fabricating and welding the performance qualification test weldment related to this learning activity.
6. Observe trainee following safe arc welding practices.
7. Observe trainee operating gas tungsten arc welding equipment.
8. Visually inspect and bend test the trainee's workmanship sample.
9. Prepare trainee for the layout, fitup, weld symbol interpretation and welding elements of performance qualification for visual examination and bend testing or radiography.
10. Administer performance qualification testing in accordance with the requirements of AWS QC12, WPS AWS2-1-GTAW or AWS2-1.1-GTAW and Drawing #AWS3–6.
11. Keep training records reflecting results of performance qualification testing for Drawing #AWS3–6.

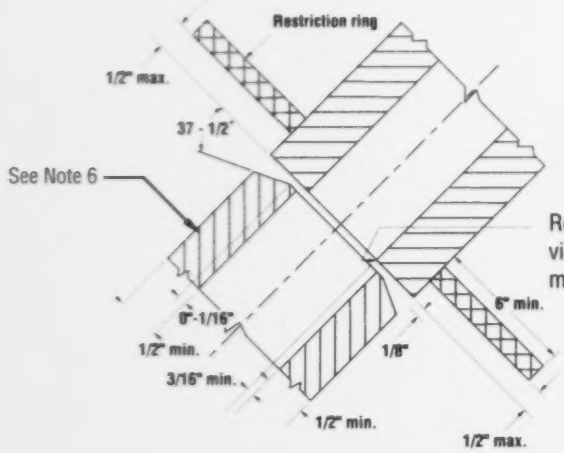
***Note:** **Performance Qualification is mandatory for Level III–Expert Welder Qualification. However, Performance Qualification for Learning Objective #12 may be substituted by Performance Qualification testing using the AWS QC7 option specified in section 4.2.4.3 *GTAW Performance Qualifications* of this guide. Where performance qualification is substituted for performance qualification under the AWS QC7 option, the trainee shall not be required to perform the performance qualification test for this learning objective.**

Figure 2 – Level III – Expert Welder, SMAW, Carbon Steel 6GR, Performance Qualification Test.



PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6GR (Multiple Welding Test Position With Restriction Ring)



DETAIL "A"

Root face of thicker section partially visable after welding. Welder shall not melt root edge of thicker section.

INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using the AWS QC7 option.
2. 12" Ø Schedule 80 M-1/P-1/S-1 carbon steel pipe. Other Schedules of pipe 6" Ø or greater may be used provided the requirements for minimum offset root and minimum wall thickness can be met. See Detail "A".
3. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
4. Without backing. Restriction ring to suit diameter of pipe.
5. All welding done in position.
6. All parts may be mechanically cut or machine OFC unless otherwise specified. I.D. of chamfered section bored to obtain a 0.500 in. (12.7 mm) minimum wall thickness. Depth of bore 1 1/2 in. minimum. Refer to Detail "A".
7. Use WPS AWS3-SMAW-1.
8. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8. Except as specified in AWS EG4.0, Section 4.2 Performance Qualification. Machine bend test coupons to dimension of thinner wall thickness of two mating sections prior to bending.

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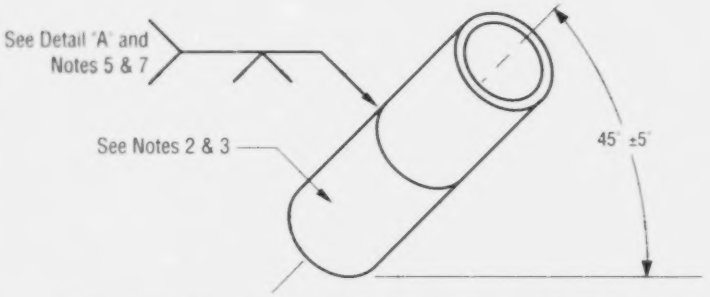
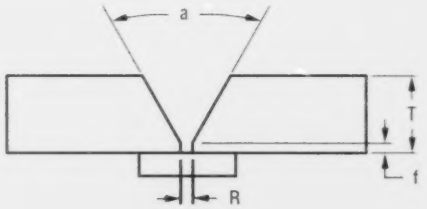
TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10', -5'		Level III - Expert Welder — SMAW — Carbon Steel 6GR—Performance Qualification			
DR BY: D. Cantelope	DATE: 6/2/96	SIZE	QC NO: 12-96	DWG NO: AWS3-1	REV:
CHK BY: R.V. Reeve	DATE: 6/2/96	APPROVED: AWS-EGC 6/2/96		SHEET: 1 of 1	

Figure 3 – Level III – Expert Welder, SMAW, Stainless Steel 6G, Performance Qualification Test.



PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6G



a = 60° minimum
R = 3/16", +1/4" -1/16"
f = R/2 maximum

DETAIL "A" - Joint Geometry With Backing

INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using the AWS QC7 option.
2. 2 1/2" - 6" Ø Schedule 40 M1/P1/S-1 carbon steel or Schedule 10S M-8/P-8 stainless steel pipe. Pipe diameter and base metal type optional within range specified.
3. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections, each a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
4. With backing. Refer to Detail. "A". Backing ring to suit diameter and nominal wall thickness of pipe.
5. All welding done in position.
6. All parts may be mechanically cut, machine OFC or PAC.
7. Use WPS AWS2-1-SMAW for carbon steel pipe.
   Use WPS ANSI/AWS B2.1-8-023 for stainless steel pipe.
8. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8. Except as specified in AWS EG4.0, Section 4.2 Performance Qualification

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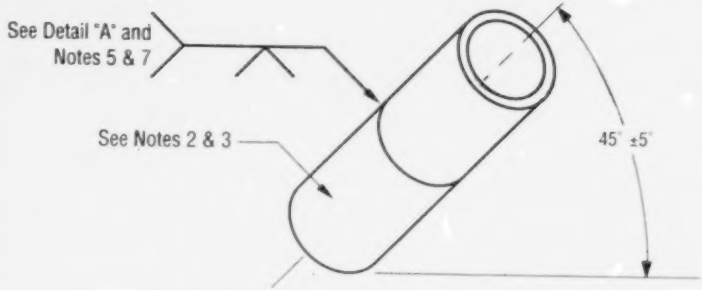
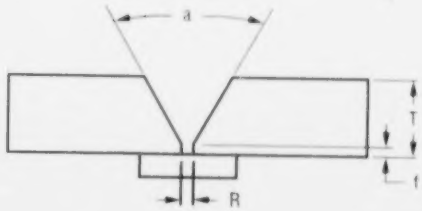
TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10' -5'		Level III - Expert Welder — SMAW — Stainless Steel 6G—Performance Qualification			
DR BY: D. Cantelope	DATE: 6/2/96	SIZE	QC NO: 12-96	DWG NO: AWS3-2	REV
CHK BY: R.V. Reeve	DATE: 6/2/96	APPROVED: AWS-EGC	DATE: 6/2/96	SHEET: 1 of 1	

Figure 4 – Level III – Expert Welder, GMAW-S, Carbon Steel 6G, Performance Qualification Test.



PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6G



a = 60° minimum
R = 3/16", +1/4" -1/16"
f = R/2 maximum

DETAIL "A" - Joint Geometry With Backing

INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using the AWS QC7 option.
2. 2 1/2" - 6" Ø Schedule 40 M-1/P-1/S-1 carbon steel pipe. Pipe diameter optional within range specified.
3. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections, each a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
4. With backing. Refer to Detail. "A". Backing ring to suit diameter and nominal wall thickness of pipe.
5. All welding done in position.
6. All parts may be mechanically cut or machine OFC.
7. Use WPS AWS2-2-GMAW .
8. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8 Except as specified in AWS EG4.0, Section 4.2 Performance Qualification.

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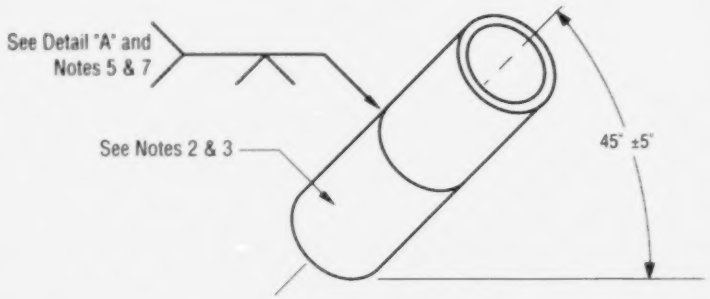
TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10 , -5°			Level III - Expert Welder — GMAW-S — Carbon Steel 6G—Performance Qualification		
DR BY: D. Cantelope	DATE: 6/2/96	SIZE:	QC NO: 12-96	DWG NO: AWS3-3	REV:
CHK BY: R.V. Reeve	DATE: 6/2/96	APPROVED: AWS-EGC 6/2/96		SHEET: 1 of 1	

Figure 5 – Level III – Expert Welder, GMAW–P, Aluminum 6G, Performance Qualification Test.

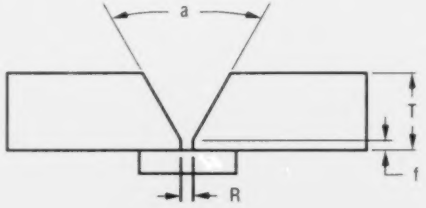
INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6G



a = 60° - 90°
R = 3/16" to 1/4"
f = 3/32" ±0"

DETAIL "A" - Joint Geometry With Backing

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using the AWS QC7 option.
2. 2 1/2" - 6" Ø Schedule 40 M-22/P-22/S-22 or M-23/P-23/S-23 aluminum pipe. Pipe diameter and material optional within range specified.
3. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections, each a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
4. With backing. Refer to Detail. "A". Backing ring to suit diameter and nominal wall thickness of pipe.
5. All welding done in position.
6. All parts may be mechanically cut or machine PAC.
7. For M-22/P-22/S-22 use WPS AWS3— GMAW-P—1.
   For M-23/P-23/S-23 use WPS AWS3— GMAW-P—2.
8. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8. Except as specified in AWS EG4.0, Section 4.2 Performance Qualification.

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TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10', -5'			Level III - Expert Welder — GMAW-P — Aluminum 6G—Performance Qualification		
DR BY: D. Cantelope	DATE: 6/2/96	SIZE	QC NO: 12-96	DWG NO: AWS3-4	REV
CHK BY: R.V. Reeve	DATE: 6/2/96	APPROVED: AWS-EGC 6/2/96	DATE:	SHEET: 1 of 1	

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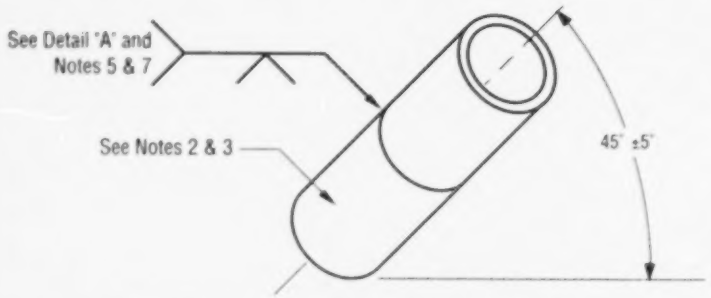
Figure 6 – Level III – Expert Welder, FCAW-S, FCAW-G, Carbon Steel 6G, Performance Qualification Test.

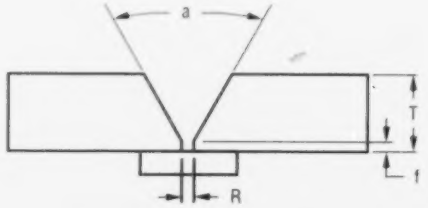
INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6G



a = 60° minimum
R = 3/16", +1/4" -1/16"
f = R/2 maximum

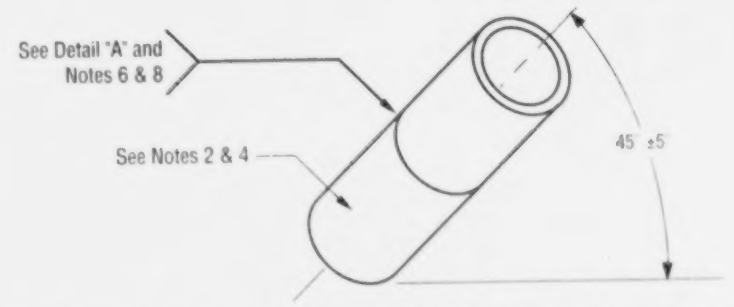
DETAIL "A" - Joint Geometry With Backing

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using the AWS QC7 option.
2. 2 1/2" - 6" Ø Schedule 40 M-1/P-1/S-1 carbon steel pipe. Pipe diameter optional within range specified.
3. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections, each a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
4. With backing. Refer to Detail. "A". Backing ring to suit diameter and nominal wall thickness of pipe.
5. All welding done in position.
6. All parts may be mechanically cut or machine OFC.
7. For FCAW-S use WPS ANSI/AWS B2.1-027.
   For FCAW-G use WPS ANSI/AWS B2.1-020.
8. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8. Except as specified in AWS EG4.0, Section 4.2 Performance Qualification.

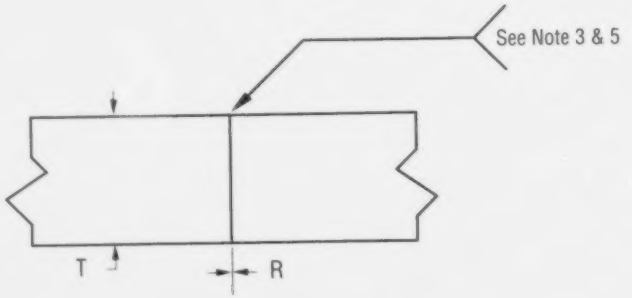
American Welding Society

TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10', -5'		Level III - Expert Welder—FCAW-S, FCAW-G—Carbon Steel 6G—Performance Qualification			
DR BY: D. Cantelope	DATE: 6/2/96	SIZE:	QC NO: 12-96	DWG NO: AWS3-5	REV:
CHK BY: R.V. Reeve	DATE: 6/2/96	APPROVED: AWS-EGC 6/2/96		SHEET: 1 of 1	



ROUND TUBING OR PIPE INCLINATION FIXED (45° ±5°) AND NOT ROTATED DURING WELDING

TEST POSITION 6G



R = T/2 (minimum) — T (maximum)
T = 0.05" — 0.120".

Detail "A" - without backing

INCH	MM
1/16	1.6
1/8	3.2
1/4	6.4
1/2	12.7
1	25.4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Notes:

1. Duplicate performance qualification tests are not required if welder is tested under AWS QC12 using AWS QC7 option.
2. 2 1/2" Ø carbon steel, stainless steel and aluminum round tubing (0.05" - 0.14" wall thickness) or Schedule 40 (aluminum or carbon steel)or 10S pipe (0.120" wall thickness). Round tubing diameter and wall thickness optional within range specified. Pipe Schedule optional according to material requirements.
3. Round tubing or pipe wall thickness greater than 0.0625" chamfer both pipe sections to form V-groove. Round tubing less than or equal to 0.0625" wall thickness use Square-groove.
4. The standard pipe groove test weldment for performance qualification shall consist of two pipe sections, each a minimum of 3 in. (76 mm) long joined by welding to make one test weldment a minimum of 6 in. (150 mm) long.
5. Without backing. Refer to Detail "A". Root shielding required. Consumable insert required for one stainless steel test. Consumable insert type optional.
6. All welding done in position.
7. Parts may be mechanically cut, machine OFC or machine PAC.
8. For carbon steel use WPS ANSI/AWS B2.1.008.
   For stainless steel use WPS ANSI/AWS B2.1.009, ANSI/AWS B2.1.010, AWS3—GTAW—1, or AWS3—GTAW—2.
   For aluminum use WPS AWS2-1-GTAW or AWS2-1.1-GTAW.
9. Visual examination in accordance with the requirements of QC12, Table 1. Bend test or Radiograph in accordance with the requirements of QC12, Table 2 and Annex D, Figures 7 and 8. Except as specified in AWS EG4.0, Section 4.2 Performance Qualification.

American Welding Society

TOLERANCES (Unless Otherwise Specified) DO NOT SCALE DRAWING Fractions: ± 1/16" Angles: + 10', -5'	Level III - Expert Welder—GTAW — 6G Performance Qualifications			
DR BY: D. Cantelope DATE: 6/2/96	SIZE:	QC NO: 12-96	DWG NO: AWS3-6	REV:
CHK BY: R.V. Reeve DATE: 6/2/96	APPROVED: AWS-EGC 6/2/96	DATE:	SHEET: 1 of 1	

Figure 7 – Level III – Expert Welder, GTAW, Carbon Steel, Stainless Steel and Aluminum 6G, Round Tubing Performance Qualification Qualification Tests.

4. Optional Welder Qualification — AWS QC7 — AWS Certified Welders

4.1 General Guidelines — AWS QC7

4.1.1 Scope. This section establishes guidelines for QC12 Participating Organizations to qualify and certify Level III – Expert Welder performance qualification tests at an AWS QC4, *Accredited Test Facility* using the AWS QC7, *Standard for AWS Certified Welders*. All welder performance qualifications listed herein are done so using AWS QC7 Supplement G, *AWS Performance Qualification Test*, and AWS B2.1, *Standard for Welding Procedure and Performance Qualification*. The purpose of AWS QC7 is to document the ability of welders to deposit sound welds (qualify) and to impose controls on the documentation and maintenance of certification (certify). The AWS QC7 standard contains criteria for the *AWS Certified Welder Program* and the *AWS National Registry of Welders*. In many cases welder qualification under the QC7 program allows transfer of welder qualification from employer to employer. This potential transfer of welder qualification may affect financial savings to the welding industry. AWS Accredited Test Facilities operate under the requirements of AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program*.

Current AWS QC7 Certified Welders shall be recognized as having met the requirements for AWS QC12 Expert Welder performance qualifications, provided said certifications meet or exceed the requirements set forth in the AWS QC12 Level III – Expert Welder Program and **4.1.7** of this guide.

4.1.2 Program. Optional Level III – Expert Welder performance qualification shall conform to AWS QC12 Level III – Expert Welder Program requirements for welder performance qualification testing administered at an AWS QC4 – Accredited Test Facility through the AWS QC7 – Certified Welder Program.

4.1.3 Testing Facility. Optional Level III – Expert Welder performance qualifications, for the AWS QC12 Level III – Expert Welder Program, shall be conducted by an AWS Accredited Test Facility and conform to the rules of AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program*. Arrangements for site testing at the Participating Organization's training facility may be conducted provided the Accredited Test Facility is approved for remote location testing.

4.1.4 Certification Requisites. Individuals desiring optional QC7 welder certification shall provide documentation showing successful completion of a three part written examination in accordance with the requirements of AWS QC12 and section 1.3 of this guide, prior to the administration of performance qualification testing. Applicants applying for optional QC7 certification shall meet the requisites specified in AWS QC7, *Standard for AWS Certified Welders*, 5. Certification Requisites.

4.1.5 Testing. Participating Organizations may elect to substitute any of the performance qualifications listed in **4.2** *Performance Qualifications*, for the performance qualification tests required by AWS QC12 and detailed in **3,** *Curriculum Guidelines* of this guide. Substituted performance qualifications shall cover all aspects of the replaced performance qualification test, with respect to welding process, welding positions, base metal, filler metal and product form.

4.1.6 Retests. If an optional Level III – Expert Welder performance qualification test fails to meet the requirements for visual examination and bend testing, a retest may be allowed as specified in AWS QC7, *Supplement G*, section G7.

4.1.7 AWS QC7 Certified Welders. Current AWS QC7 Certified Welders desiring AWS QC12 Level III Expert Welder Certification may apply for completion status of any mandatory welder performance qualification test within the AWS QC12 Expert Welder Program. AWS QC7 Certified Welders desiring recognition as having met the requirements for welder performance qualification testing as set forth in the AWS QC12 Level III – Expert Welder Program shall meet the following conditions:

1) The applicant's AWS QC7 certification meets or exceeds the requirements set forth in the AWS QC12 Level III – Expert Welder Program for any welder performance qualification test being superceded by the current certification.

2) At the time of application for recognition, the AWS QC7 Certified Welder shall produce his/her certification card(s) and present it to the AWS QC12 Facility Representative for review. The card(s) expiration date(s) shall be current. The card shall be maintained in good condition.

3) The AWS QC12 Facility Representative shall record the AWS QC7 Welder's certification number and test description. Prior to recognition the Facility Representative shall contact the AWS Certification Department to verify the applicant's current status. The Facility Representative may request from AWS Certification a detailed description of the applicant's certification so compatibility with AWS QC12 performance qualifications can be ascertained.

4) The AWS QC7 Certified Welder and the AWS QC12 Facility Representative shall be aware that the card is the property of the American Welding Society. Evidence of tampering with the card shall be sufficient cause for rejection of recognition and shall require return of the card to the AWS Certification Department for investigation. An investigation by the Certification Committee may result in dismissal of the charges, suspension, revocation of certification, or renewal qualification, depending upon circumstances. The Committee will provide an explanation for its actions.

5) AWS QC7 Certified Welders applying for AWS QC12 Level III - Expert Welder Certification whether through training, examination and testing or testing and examination alone shall meet all requirements for written examination, performance qualifications and work experience in accordance with AWS QC12 Level III – Expert Welder Program rules prior to issuance of certification.

4.1.8 Other Codes or Standards. Participating Organizations desiring welder performance qualification testing using the AWS QC7 option of AWS QC12 may substitute the performance qualifications listed in **4.2** *Performance Qualifications*, with any recognized standard or qualified welding procedures independently developed by an employer provided the following conditions are met:

1) The performance qualification test specified by the standard or employer's welding procedure satisfies or exceeds the performance qualification requirements of AWS QC12, *Specification for Qualification and Certification for Level III – Expert Welders*.

2) Performance qualification tests are administered using AWS QC7, Supplement G at an AWS Accredited Test Facility.

3) The performance qualification test is within the limits of AWS QC12 Level III – Expert Welder certification and meets or exceeds conditions for welding process, position, base metal, filler metal and product form.

4) A procedure qualification test is conducted and the results recorded on a Procedure Qualification Record (PQR) for joints that are not prequalified

5) The Participating Organization submits a Welding Procedure Specification documenting the essential welding variables for the standard or employer's welding procedures at the time the performance qualification test is administered by the AWS Accredited Test Facility.

6) The standard or employer's welding procedure meets or exceeds the requirements for visual examination and bend testing of AWS B2.1, *Standard for Welding Procedure and Performance Qualification.*

4.2 Performance Qualifications.

4.2.1 Shielded Metal Arc Welding (SMAW) Performance Qualifications

4.2.1.1 SMAW Carbon Steel Pipe. Optional performance qualification testing for carbon steel pipe shall be conducted using WPS AWS3–SMAW–1 and Drawing #AWS3–1 (see Figure 2). This performance qualification test supersedes the performance qualification test for Course F, Unit #2, Learning Objective #7 of this guide except as noted[1, 2, 3].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

[3]Root face of thicker section partially visible after welding. Welder shall not melt root edge of thicker section. Machine bend test coupons to dimension of thinner wall thickness of two mating sections prior to bending.

4.2.1.1 SMAW Stainless Steel. Optional performance qualification testing for stainless steel shall be conducted using carbon steel or stainless steel pipe, stainless steel electrodes, AWS3–SMAW–1 or ANSI/AWS B2.1–8–023 and Drawing #AWS3–2 (see Figure 3). This performance qualification test supersedes the performance qualification test for Course F, Unit #2, Learning Objective #8 of this guide except as noted[1, 2].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the governing document.

4.2.2 Gas Metal Arc Welding (GMAW–S, GMAW) Performance Qualifications

4.2.2.1 GMAW–S Carbon Steel Pipe. Optional performance qualification testing for carbon steel pipe shall be conducted using WPS AWS2–2–GMAW and Drawing #AWS3–3 (see Figure 4). This performance qualification test supersedes the performance qualification test for Course F, Unit #3, Learning Objective #7 of this guide except as noted[1, 2].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

4.2.2.2 GMAW-P Aluminum Pipe. Optional performance qualification testing for aluminum pipe shall be conducted using WPS AWS3.1.1 — GMAW-P. for (M-23/P-23/S-23) or WPS AWS3.1.2 — GMAW-P (for M-22/P-22/S-22) and Drawing #AWS3–4 (see Figure 5). This performance qualification test supersedes the performance qualification test for Course F, Unit #3, Learning Objective #8 of this guide except as noted[1, 2].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for otherstandards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

4.2.3 Flux Cored Arc Welding (FCAW–S, FCAW–G) Performance Qualifications

4.2.3.1 FCAW–S Carbon Steel Pipe. Optional performance qualification testing for carbon steel pipe shall be conducted using WPS ANSI/AWS B2.1–1–027 and Drawing #AWS3–5 (see Figure 6). This performance qualification test supersedes the performance qualification test for Course F, Unit #4, Learning Objective #7 of this guide except as noted[1, 2].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

4.2.3.2 FCAW–G Carbon Steel Pipe. Optional performance qualification testing for carbon steel pipe shall be conducted using WPS ANSI/AWS B2.1–1–020 and Drawing #AWS3–5 (see Figure 6). This performance qualification test supersedes the performance qualification test for Course F, Unit #4, Learning Objective #8 of this guide except as noted[1, 2].

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

4.2.4 Gas Tungsten Arc Welding (GTAW) Performance Qualifications

4.2.4.1 GTAW Carbon Steel Round Tubing or Pipe. Optional performance qualification testing for carbon steel round tubing shall be conducted using WPS ANSI/AWS B2.1.008 and Drawing #AWS3–6 (see Figure 7). This performance qualification test supersedes the performance qualification test for Course F, Unit #5, Learning Objective #10 of this guide except as noted.[1, 2,3]

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

[3]All GTAW performance qualification tests are open root, no backing with root shielding except where consumable inserts are specified.

4.2.4.2 GTAW Stainless Steel. Optional performance qualification testing for stainless steel shall be conducted using carbon steel or stainless steel round tubing or pipe, with and without a consumable insert, stainless steel filler metals, WPS AWS3–GTAW–1 or ANSI/AWS B2.1-009 and Drawing #AWS3–6 (see Figure 7). This performance qualification test supersedes the performance qualification test for Course F, Unit #5, Learning Objective #11 of this guide except as noted.[1, 2,3,4]

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

[3]All GTAW performance qualification tests are open root, no backing with root shielding except where consumable inserts are specified.

[4]Two performance qualification tests are required for AWS QC12 GTAW stainless steel certification. One test shall be without a consumable insert and the other with. The consumable insert type is optional and shall be stainless steel material.

4.2.4.3 GTAW Aluminum Round Tubing or Pipe. Optional performance qualification testing for aluminum round tubing shall be conducted using WPS AWS2-1-GTAW or WPS AWS2-1.1-GTAW and Drawing #AWS3–6 (see Figure 7).This performance qualification test supersedes the performance qualification test for Course F, Unit #5, Learning Objective #12 of this guide except as noted.[1, 2,3]

Note: [1]Visual Examination, bend testing and/or radiography in accordance with the requirements of AWS B2.1, Standard for Welding Procedure and Performance Qualification.

[2]Visual Examination, bend testing and/or radiography for other standards or employer's qualified welding procedure specification in accordance with the requirements of the particular fabricating document.

[3]All GTAW performance qualification tests are open root, no backing with root shielding except where consumable inserts are specified.

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5. Optional Written Examination — AWS QC1 — AWS Certified Welding Inspectors

5.1 General Guidelines

5.1.1 Scope. This section establishes guidelines for QC12 Participating Organizations to provide an optional alternative to Level III – Expert Welder written examination. Alternative written examination may be conducted at an AWS approved exam site using an AWS Test Supervisor in accordance with the AWS QC1, *Standard for AWS Certification of Welding Inspectors* for administration of the AWS QC1, *Certified Welding Inspector Examination*. All candidates for AWS QC12 Level III – Expert Welder certification have sufficient work experience and training to qualify as either AWS QC1 Certified Welding Inspectors or Certified Associate Welding Inspectors. The competencies and experience required for welding inspection are also part of a Level III – Expert Welder's training and qualification.

The purpose of welding inspection is to determine if a weldment meets the acceptance criteria of a specific standard or other document. The welding inspector must be thoroughly familiar with welding processes, welding procedures, welder qualifications, materials, the limitation of weld testing, be able to read drawings, prepare and keep records, prepare and make reports and make responsible judgements. So too, must the Level III Expert Welder.

Current AWS QC1 Certified Welding Inspectors (CWI) or Certified Associate Welding Inspectors (CAWI), with QC1 CWI examination scores 72% or higher, shall be recognized as having met the requirements for AWS QC12 Expert Welder written examination provided they pass a supplemental safety examination with a minimum passing score of 90%.

5.1.2 Education and Experience Requirements.

5.1.2.1 Each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Welding Inspector (CWI):

1) Shall meet the education and experience requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, 5. Education and Experience Requirement (section 5.1 inclusive).

2) Shall meet the AWS QC12 work experience requirement of a Level III - Expert Welder with no formal training who applies for AWS QC12 certification through examination and testing.

5.1.2.2 Each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Associate Welding Inspector (CAWI):

1) Shall meet the education and experience requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, 5. Education and Experience Requirement (section 5.2 inclusive).

2) Shall meet the AWS QC12 work experience requirement of a Level III - Expert Welder with formal training (Entry Level Welder and Level II - Advanced Welder) who applies for AWS QC12 certification through training, examination and testing.

5.1.3 Examination Requirements.

5.1.3.1 All Level III – Expert Welder applicants for the AWS QC12 option for QC1 examination shall pass a supplemental safety examination with a minimum passing score of 90%.

5.1.3.2 Each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Welding Inspector (CWI):

1) Shall meet the examination requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, section 6., 6.1.1 for eye examination.

2) Shall meet the examination requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, sections 6., 6.1.2, 6.1.3, 6.1.4, 6.1.5 for written examination except as noted in 3) below.

3) To supercede the requirements for written examination in accordance with AWS QC12, each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Welding Inspector (CWI) shall pass the AWS QC1 Certified Welding Inspector Examination with a minimum cutoff score equal to or greater than the passing score required for CWI.

5.1.3.3 Each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Associate Welding Inspector (CAWI):

1) Shall meet the examination requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, section 6., 6.1.1 for eye examination.

2) Shall meet the examination requirements of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, sections 6., 6.1.2, 6.1.3, 6.1.4, 6.1.5 for written examination except as noted in 3) below.

3) To supercede the requirements for written examination in accordance with AWS QC12, each Level III – Expert Welder applicant for the AWS QC12 option for QC1 examination and certification as a Certified Associate Welding Inspector (CAWI) shall pass the AWS QC1 Certified Welding Inspector Examination with a minimum cutoff score equal to or greater than the passing score required for CWI.

5.1.4 AWS QC1, Certified Welding Inspectors (CWI) and Certified Associate Welding Inspectors (CAWI).

5.1.4.1 All current CWI's desiring to supercede AWS QC12 written examination requirements for Level III – Expert Welder shall pass a supplemental safety examination with a minimum passing score of 90%.

5.1.4.2 All current CAWI's, with minimum AWS QC1 passing scores of 72%, desiring to supercede AWS QC12 written examination requirements for Level III – Expert Welder shall pass a supplemental safety examination with a minimum passing score of 90%.

ANNEX A
Recommendations for Support Personnel and Systems

A1.0 Program Administrator.

The administrator, director, or supervisor of any welding program should be familiar with all types of welding. A practical background in the welding industry would be very helpful. In addition to meeting the minimum state certification requirements, the program administrator should be experienced in both instruction and program execution.

Because of the importance of continued contact with area industry, the administrator should be encouraged to join and maintain a membership in the American Welding Society and be active in the local AWS Section. Membership in other professional organizations, particularly in the materials (metals) or educational field, would also be very helpful. Such participation will allow a welding program administrator to maintain effective working relationships with members of local industry, technical experts, and fellow educators. Moreover, the administrator's commitment to these activities sets the example for not only the instructors but also the welding personnel.

A2.0 Business and Industry Services Liaison (BISL).

A full time liaison with no other responsibilities, representing the schools' vocational trades interests should be established. This individual should be a certified staff member with previous experience as a cooperative vocational education coordinator or a guidance counselor with job placement background. This individual should also have a strong understanding of both education and work environments. The responsibilities of the position should include:

- Formation of a Business & Industry Services Unit
- Identification of prospective trainees
- Assisting students to successfully fulfill all the proposed school requirements
- Administration and maintenance of records, coordination of student placement
- Conducting follow-up trainee surveys
- Teaching of the employability skills curriculum
- Maintaining close cooperation with the Advisory Council or Private Industry Council

The *"BISL"* is the direct contact with the Advisory or Private Sector Coordinator.

A2.1 Business and Industry Services Unit (BISU).

A team of professionals from the BISU coordinates the trades initiative. Under the direction of the Business Industry Services Liaison (BISL), the unit serves as the in-school component, for implementing a series of coordinated activities on a daily basis, designed to assist trainees, to acquire prerequisite skills and experiences needed to secure and retain full time employment upon graduation of their respective programs. The unit coordinates its activities with the Advisory Council. The BISU should consist of:

- Business Industry Services Liaison
- Site Principal or President
- Basic Skills Coordinators
- Bilingual and/or ESL Coordinators
- Guidance Staff
- Vocational Education Coordinator

The *"BISU"* has the responsibility to coordinate and conduct activities for:

- Assessment and interpretation of a trainee's interests and abilities with employment services
- Providing career seminars for trainees
- Maintaining a career resource center
- Delivering a computerized guidance information system
- Activating parent groups
- Implementing shadowing, internship, and apprentice experiences for students
- Developing part-time/summer job placement and full time job placement
- Conducting program evaluations
- Developing trainee career profiles
- Development of a yearly action plan
- Meeting monthly to discuss each trainee
- Developing individualized instruction to assist each participant to complete program requirements
- Developing activities in coordination with members of the Advisory Council to implement program objectives
- Plan meetings with the Advisory Committee on a periodic (quarterly) basis

A3.0 Advisory Council.

The Council comprises a group of selected individuals based on their knowledge and expertise to advise those involved in the training initiative on: current labor needs, development of relevant courses/programs, and the competencies offered in each of the courses or programs. This unit in not housed within the confines of each training system, but its members are called upon frequently to assist in the development of individualized student programs. The Advisory Council consists of:

- Private Sector Coordinator (representing either JTPA or PIC)
- Job Placement Coordinator
- District Curriculum Coordinator (for grades 7–12)
- Employment Service Representative
- Parent (PTA/PTO) Representative (secondary institutions)
- Business and Industry Representative
- Organized Labor Representative
- Military Representative (for areas of civilian employment served by the Armed Forces)

A4.0 Private Sector Coordinator.

The Private Sector Coordinator is a full time employee of the State Department of Labor (JTPA/PIC) located within each program service delivery area. Private Sector Coordinators work closely with business and industry to develop part time/summer and full time jobs, as well as compile and update jobs. These jobs are then provided to the employment service for use in a computerized job bank to match identified eligible trainees to summer and full time jobs. The Private Sector Coordinator's function is to:

- Develop cooperative agreements with the training facilities of their designated areas (terms for state program funding)
- Offer liaison with all schools or training facilities within their jurisdiction
- Be responsible for bringing together representatives of business and industry

- Report to the Private Industry Council (PIC) director/chairman of their designated area in carrying out the terms of the cooperative agreement (JTPA) or similar state and federally administered models
- Coordinate PIC and LEA (school board) groups to assist eligible youth with the opportunity to participate in other services provided by the Private Industry Council (tuition refunds, travel allowances, food, clothing, tools, etc.)

A5.0 Advisory Committee.

The Committee is a conglomerate of all interested training incentive sectors. It assists in the advertisement of program implementation, formulation of trainee learning contracts, informing training facility personnel and the community about the program, providing orientation for potential training candidates, their spouses and or parents, planning and implementing "launching" activities, review of final reports and evaluations, and the review of follow-up surveys. The Committee is comprised of:

- Business Industry Services Liaison (chairperson)
- Local section representative of the American Welding Society (AWS).
- Assistant Superintendent of Schools or Assistant President of the College Board of Regents
- Human Resource Development Director or Director of Guidance
- Cooperative Education Coordinators
- Parent Representative (secondary systems)
- Trainee Representative (Level - III, should have an active voice in training)
- Members from a school district offering a comprehensive welding curriculum
- Community Agency Representatives
- Business and Industry Representatives:
  - Welding Engineer
  - Welding Inspector
  - Welding Technician
  - Welding Supervisor
  - One or two experienced welders
  - Welding supply representatives
- Private Industry Council Representative
- State Employment Representative

The duties of the Advisory Committee may vary according to the preferences and composition of the representatives from the geographical area and various state models. However, the baseline duties should include the following:

- Providing advice and assistance in the selection, purchase, and installation of equipment appropriate to both the instructional environment and the requirements of modern industry.
- Assisting in the development and implementation of continuing education experiences, including advanced course work, for welding educators.
- Assisting with the preparation and review of instructional materials and the ongoing development of instructional pedagogy.
- Fostering participation in appropriate community service and educational projects, stressing the value of such activities as an excellent means of recruiting and motivating individuals.

- Encouraging welding personnel to apply for scholarships and enter competitions sponsored by such entities as the American Welding Society (AWS), Vocational Industrial Club of America (V.I.C.A.), and other educational opportunities.
- Helping with follow-up surveys of graduates who have been successfully placed in welding-related occupations.
- Supporting the program through assistance in public relations and welding personnel recruitment.
- Sponsoring career days, plant tours, and related activities designed to stimulate interest in welding and related fields as possible career opportunities.
- Provide assistance in obtaining welding practice materials.
- Provide internship opportunities in area businesses.

A6.0 AWS Certified Welding Educator (AWS QC5).

The Welding Instructor is a person who recognizes welding training requirements, prepares instructional plans, conducts training classes and evaluates welding personnel performance. This instructor may teach using prepared instructional materials or prepare original instructional materials. Most states require instructor certification which includes meeting selective academic standards and demonstrating experience from that related industry.

The instructor should be certified by AWS QC5, *Standard for Certification of Welding Educators.* The instructor should also be certified by AWS QC7, *Standard for AWS Certified Welders* in the processes, positions, base metals, and filler materials involved with the courses being taught.

Instructors should be responsible for continually updating their technical knowledge. Furthermore, it is incumbent upon welding instructors to strive to enhance their own teaching abilities. Welding instructors will find participation in the programs of appropriate industry and educational associations beneficial to their effectiveness as educators. On a regular basis, instructors, as members of AWS, should visit local industry, attend area welding educational programs sponsored by local AWS sections and/or the annual AWS International Welding Exposition in order to stay up–to–date on the latest technological trends. Industry and trade magazines provide another excellent means of continuing education and many are available to educators free of cost. Attitude, demeanor, and dedication to the welding industry are essential qualities as instructors set the example for their welding students.

A7.0 AWS Certified Welder Program (AWS QC7).

The primary program for Level III – Expert Welder Training is AWS QC12, Specification for Qualification and Certification for Level III – Expert Welder. The AWS Certified Welder program is for advanced trainees and experienced welders seeking certification to a particular welding code as AWS Certified Welders.

The American Welding Society (AWS) Certified Welder Program was established to identify all elements necessary to implement a National Registry of Certified Welders. The four key elements of this standard (AWS QC7, *Standard for AWS Certified Welders*) include:

- Welder performance qualification standards
- Standard welding procedure specifications
- Accredited performance qualification test facilities
- AWS welder certification requirements

The QC7 standard contains the criteria for the AWS Certified Welder Program and the AWS National Registry of Welders. The purpose of this standard is:

- To determine the ability of welders to deposit sound welds in accordance with standardized requirements.
- To impose sufficient controls on the documentation and maintenance of certification to allow transfer between employers without requalification, where allowed by standard or contract documents.

Applicants, upon successful completion of qualification testing, become certified, and are issued an identification/qualification limits card encased in plastic. This identification/qualification limits card shall be used to identify certified welders and their limits of certification. The AWS certification of a welder is effective for a period of one year from the date of certification. Prior to the end of the certification period, an application for recertification may be made if:

- The welder retests.
- The welder submits form QC–WF3 attesting to having welded satisfactorily in each six month period of the one year with the processes qualified for.

A8.0 AWS Accredited Test Facilities (AWS QC4).

AWS Accredited Test Facilities are designed to implement the QC7 program. Under this program instructors may not test and qualify welders they have trained. In the QC12 program for expert welders, instructors are afforded the latitude of training, testing and qualifying trainees if the code/standard qualification option ***is not*** *exercised.*

AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program*, establishes minimum requirements for Test Facilities, their personnel, and equipment to qualify for accreditation to test and qualify welders in the AWS Certified Welder Program. This facility accreditation program is open to all Test Facilities that are qualified, whether or not they are members of AWS. The Test Facilities may be part of an independent laboratory, manufacturing plant, educational institution, or other party.

The purpose of a third-party accreditation of Test Facilities for welder qualification is to confirm that a Test Facility has the personnel, organization, experience, procedures, knowledge, equipment, capability, and commitment to conduct proper welder qualification testing for the AWS Certified Welder Program. AWS QC4 describes the requirements and functions of the Test Facility to achieve this purpose and to complete reliable reports and to define the relationships between the Test Facility and the other parties involved.

The AWS Accredited Test Facilities conduct welder qualification tests for the AWS Certified Welder Program. A person wishing to take tests to become an AWS certified welder prepares, an application in accordance with AWS QC7. The applicant is responsible for contacting the Test Facility to arrange a specific date and time for the completion of the qualification test assembly. All acceptable test results and records will be forwarded to AWS by the Test Facility after the welder qualification test is completed.

A9.0 Safety Requirements.

All schools shall develop and enforce sound safety programs, beginning with the orientation of welding personnel and continuing through graduation. Each school shall teach safety theory and practice safety at all times. All safety practices shall conform to local, state, and federal regulations, and ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*; ANSI/AWS F2.2, *Lens Shade Selector*; ANSI/AWS F3.1, *Guide for Welding Fume Control*; ANSI/AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting of Containers That Have Held Hazardous Substances* and general work place safety.

A10.0 Evaluations.

The purpose of the evaluation program is to directly and efficiently respond to the identified needs of:

- Diverse trainee populations
- Corporate training institutions
- The communities and industries served

Responding to these needs improves each trainee's opportunity for access to training and increasing the numbers of students completing training objectives related to the service needs of the employing community.

The process should include administering diagnostic assessment instruments to determine the prospective training clients' current knowledge, attitude, skills, and habits (KASH) as contrasted to the clients initial career interest. In addition, this evaluation should define and implement duties, role relationships and tasks of the instructional and supportive advisement staff to deliver appropriate services generated from the diagnostic assessment system.

As each step of training is completed, the results of both written and performance tests should be communicated to each individual and duly recorded in an appropriate format. The number of hours of welding theory and practice completed, by process, should also be recorded. The purpose of this information is to develop a career profile for each trainee.

The program evaluations should be three-phase:

- **Formative:** To measure learning progress at each step of the program and provide diagnostic prescriptions for learning problems that require remedial work.

- **Summative:** To determine if the learner has mastered the learning tasks to such a degree that he/she may move to the next course, unit or level of instruction, and to determine some type of grade assignment.

- **Follow-up:** To measure the trainee's effectiveness on the job and the training facility's delivery of the instructional programs. Follow up evaluation is meant to determine whether the school or facility has met the needs of industry. Follow-up surveys are used by the Advisory Council and Advisory Committee to track program performance and to make prescriptive recommendations for weak training areas.

ANNEX B
Recommendations for the Trainee Population

B1.0 Entrance Requirements.

B1.1 Career Guidance.

The success of recruiting prospective individuals into the welding field will depend on the pre-placement assessment, testing and guidance provided to that individual. The Business Industry Services Unit personnel should emphasize the very real opportunities inherent in choosing welding as a career path. Current and long-term needs for skilled welders demand that career counselors present welding as a positive career. Business Industry Services Unit personnel and the Advisory Committee members play an important role in ensuring that career counselors and the administrative committee have regular, positive contact with the welding industry through plant tours, open houses, and personal contacts. Guidance counselors must be made aware that welding not only provides an excellent entry level career, but can also provide preparation for positions such as welding supervisor, quality assurance inspector, production scheduler, etc. Moreover, career enhancement should not cease once training is completed. The Instructors and the Advisory Committee should work with the Business Industry Services Unit to place graduates in appropriate positions and to track their subsequent successes.

B1.2 Basic Prerequisites.

Standards for admittance to the welding program should be established by formal evaluation of prospective welding personnel. A basic foundation in computation, physical science, learning to learn, reading, writing, problem solving abilities, creative thinking, interpersonal skills and teamwork is necessary if a person is to have a successful career in welding. In the event that some prospective welding personnel do not demonstrate the academic skills necessary to understand the subject matter, a "remedial" program, at the same location or nearby training facility, should be set up to provide the missing academic foundation necessary for welding training.

B1.3 Aptitude.

Each training program should incorporate some form of pre-placement test(s) to help screen and orient prospective welding personnel. There should be some form of diagnostic assessment and academic advisement. Whether or not they are used specifically for screening, a welding aptitude test can provide valuable insight into an individual's unique educational abilities and needs. As an example, welding simulators are one aid available to assist in this determination. Both written exercises and tests for manual dexterity, should be considered when evaluating the prospective individual's overall aptitude.

B1.4 Health.

Safe operation of the welding equipment and maintaining a work environment appropriate to the welding industry are paramount. Prospective welder trainees should have the ability to meet these critical requirements.

B1.5 Age.

Individuals must meet the minimum age requirements stipulated by applicable state and federal laws.

B1.6 Probationary Period.

All trainees should be given a trial period in which to demonstrate their ability to perform, and develop good work habits as required by industry. The time limit for such a period will vary according to the institution and type of instruction, but should not exceed 15 percent of the course length. A public school situation may permit a longer time, versus that allowed by a private or industrial training program. During this probationary period, the educator must determine whether, in the interests of all concerned, the individual should continue the course of instruction.

B2.0 Trainee/Instructor Ratio.

The trainee–instructor ratio for each course should be kept as low as possible. A reasonable figure would be fifteen (15) welding personnel to one (1) welding instructor. However, this ratio should never exceed the number of work stations in the laboratory. Twenty (20) welding personnel to one (1) instructor would be the maximum acceptable ratio.

B3.0 Trainee/Machine Ratio.

Only one (1) individual should be assigned to a power source at a time. Placing more than one (1) individual in a booth or work station is unacceptable for positive training, disciplinary purposes, and safety.

ANNEX C
Recommendations for Facility Planning

C1.0 School Facilities.

C1.1 Primary Structure(s).

The building should be fireproof and well designed. Welding instructional facilities will function best if located on the ground floor, preferably in a one story wing of the main building or in a separate building with covered access ways. Instructional areas in which noisy activities are conducted are best placed farthest from other academic areas of the school or production areas in an industrial facility. Walls should be smooth, with no ledges to collect dust. Floors must be fire resistant, waterproof, and contain adequate floor drains. A minimum light level of 100 foot-candles (100 candela) 30 inches (762 millimeters) from the floor is recommended. To enhance motivation and morale, adequate natural light from windows and skylights should be available. Walls should be prepared with a low reflective paint to reduce ultraviolet radiation. "Cool" colors, blues or greens, are recommended. The various work stations in a laboratory should meet the following objectives:

- Provide suitable facilities where the instructor may demonstrate the skills and techniques necessary to develop welding competencies.
- Provide a place at which the welding students may develop such competencies.
- Provide an area in which power sources, equipment and projects may be secured and serviced.
- For specific industry welding training facilities, provide special fixturing and production work mock-ups to adequately demonstrate the production work to be expected, in order to allow all students to experience typical job related welding positions, conditions, and interferences.

A modular system of layout should be considered so that a two fold criteria for modern building planning (i.e., flexibility and expandability) can be achieved. The former is accomplished by allowing the maximum possible interchange of work stations and other facilities. Future expansion is planned in terms of multiples of specific work stations needed rather than in terms of the general area to be added. These features would simplify the work of the architect, increase the usable life of the laboratory, and provide the instructor with more possibilities to offer Curriculum changes.

The flexibility and expandability of laboratories should be greatly enhanced if architectural design permits use of nonload-bearing partitions between adjoining areas. Good planning includes the provision of doors large enough to permit easy entry of the largest piece of equipment into each shop. In addition, placement of such doors to permit the maximum degree of future flexibility with changes in partition locations should be considered.

If facilities are to be used for evening classes, easily accessible outside entrances which eliminate the necessity of opening or lighting other parts of the building offer important savings in operating and maintenance costs.

C1.2 Classroom(s).

Ideally, a room for instruction should be about 20 feet (6.1 meters) X 24 feet (7.3 meters) and adjacent to the laboratory. Classrooms should provide a clear (but protective) view of the laboratory area. The minimum ceiling height should be 12 feet (3.7 meters) or higher. Classrooms must be acoustically insulated from laboratory noise. This space should have chalk and tack boards, a demonstration table, adequate seating facilities and provision for darkening for the use of visual aids. At least one bulletin board should be near the main entrance. Instructors and welding personnel must

have nominal access to the classroom. Storage for audiovisual equipment, charts, models, samples, reference texts, etc., need to be provided. Exhibit cases have strong appeal to parents and observers, especially when located to permit viewing from the outside corridor.

C1.3 Laboratory.

A minimum of 100 square feet (9.3 square meters) of laboratory floor space per individual is considered a good general planning figure, exclusive of washroom, storage, office space and the classroom. At the outset the architect and laboratory planner must take into account state recommendations as to minimum square footage per individual. While they vary from state to state, factors of 75 square feet (7.0 square meters) to 150 square feet (13.9 square meters) of work space per individual and a minimum of 400 square feet (37.2 square meters) to 800 square feet (74.3 square meters) for material storage are generally accepted requirements for this particular size area and the subjects to be taught. Floor dimensions of 40 feet (12.2 meters) X 85 feet (25.9 meters) are reasonably close to the normally accepted length to width proportions of 2 to 1. The minimum ceiling (clearance) height should be no less than 14 feet (4.3 meters). At least one entrance must be large enough 14 feet (4.3 meters) X 14 feet (4.3 meters)) to accommodate bulky materials, equipment and projects. Future expansion should always be considered. While projections of this nature are sometimes only educated guesses at best, adaptability for reorganization should be kept in mind. This should permit additional enrollment, new equipment, or extra shop subjects to be reasonably accommodated without going below space–per–individual minimums.

Where a hazard exists around machines, the power equipment should be so placed that welding personnel are not in the line of danger. Added protection is given by enclosing this equipment in a safety zone painted on the floor. Wide aisles of travel should be provided between benches, machines, and in areas in front of tool cabinets and storage lockers. These aisles should be a minimum of 3 feet (.9 meters) in width. Aisles of travel may be designated by painted lines similar to those used in industry. Non-skid surfaces such as sand on shellac should be applied to the floor in the area around machines to minimize danger of slipping.

A 6 feet (1.8 meters) X 6 feet (1.8 meters) area should be planned for process booths and ought not to contain a power source. Welding booths must be constructed of fire resistant material, with the walls open at least 12 inches (305 millimeters) at the bottom to permit air circulation. All four sides of the welding booth should provide complete protection to the welding personnel and others in the area from harmful rays and hot sparks. A minimum of one 10 feet (3.1 meters) X 10 feet (3.1 meters) demonstration area should be available for every 20 welding personnel. Positioning jigs, independent of other activities to prevent congestion, should be provided.

Tools and supplies should be located as near to work areas as practical to reduce travel and interferences. Machines should be placed to allow for ease of cleaning around the base. Cabinets should fit flush to walls or be trimmed to fit flush for the same reason. Bases for cabinets and benches should provide toe space for comfort and safety of workers.

C1.4 Office(s).

The entrance to the instructor's office should be easily accessible from the classroom, laboratory and facility corridor. Activities in the classroom and laboratory must be visible from the office. The office window space should be designed to provide maximum vision to all areas along with proper ultra violet light protection. The office ought to provide at least 120 square feet (11.2 square meters) of floor space per instructor [size 10 feet (3.1 meters) X 12 feet (3.7 meters)]. The office needs to be planned with at least one 3 foot (.9 meters) wide door, tile or carpet flooring cover, and an acoustical ceiling with fluorescent lighting. For instructional use and laboratory safety the office should have a telephone. It

should also have room for file cabinets, desk, bench with storage underneath for weld supplies, a shelf for boots, and room for two chairs for counseling welding personnel.

C1.5 Storage.

Decentralized storage should help conserve space and increase efficiency by reducing individual traffic. A storage area for bar stock should be at least 20 feet long (6.1 meters) and 7 feet wide (2.1 meters), with a door centered at both ends. This permits both economical purchase of steel in long lengths and wall storage within the room. Use of horizontal or vertical racks depends on space limitations and personal preference. Storage of bulk supplies (adequately secured) should be located adjacent to an outside service door for convenient delivery.

Adequate filler metal storage should be considered and should be controlled. Rod, wire, and fluxes, depending on their nature, must be maintained under certain storage conditions. The materials of higher value or requiring temperature control should require the tighter controls to ensure that product quality is retained. Acquisition of a specially designed electrode storage oven is highly recommended.

Open tool cabinets in each process area should conserve welding personnel time and travel while helping them associate proper tool selection and application with a particular activity. This also provides for easy checking of tools. Space underneath benches and tables is excellent for storage of hardware, small amounts of raw stock or even small projects. Storage for projects of welding personnel and personal belongings is always a problem and should be well thought out.

Cylinder storage should be located near the laboratory, but accessible to truck traffic. All volatile materials should be stored outside in an identified, isolated area to minimize the potential hazards involved. Cylinder storage **shall** follow the guidelines set forth in ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, Part II Specific Processes, 10.8.2 Cylinder Storage.

One door should open directly to the outside from this room so that stock may be loaded into the room with no interference to shop activities. Scrap storage could be located near this entrance. Thus, material storage areas or rooms should be located conveniently for issuing materials to the welding personnel, for cutting large stock to project size and for the unloading of delivery trucks.

C1.6 Personal Services.

Personal Services should be planned into the laboratory, both for convenience and efficiency. Individual lockers for books and clothing should be near the entrance to keep these items out of the main instructional area. A wash-up sink and water fountain and, where possible, a lavatory (for both genders) should also be included near the entrance.

C1.7 Budget.

Adequate financial resources should be considered and support provided to not only maintain the program, but also enhance it. Funding for power sources, filler metals, gases, and fluxes along with power equipment and hand tools are just the basics. Additional monies should be available to provide the materials necessary for adequate welding instruction. As necessary, staff and faculty should also have included in the budget resources (i.e., release time and dollars) to provide for their technical as well as professional development.

C1.8 Lighting.

100 foot-candles (100 candela) should be the absolute minimum recommended for general work in any shop while 140 foot candles (140 candela) would be recommended for more difficult or inspection work. In most cases, the use of indirect lighting to avoid glare and evenly diffused light is recommended. When needed, individual machines can be lighted by lamp attachments or through their

own built-in lighting systems. Providing uniform distribution of shadow-free light through the use of indirect or semi-indirect deflectors should also be considered. Adequate lighting shall also be found in each booth.

C1.9 Electricity.

Electrical power should be supplied with adequate voltage and amperage for each power source. Electrical service should be 208 volt, 230/240 volt or 460/480 volt, single-phase or three-phase, and 60/50 cycle (60/50 Hertz), alternating current. The primary service should never be less than 208 volts. Current capacity of 75 percent more than the known demand should be provided for expansion in the welding facility. Electrical outlets for 110/120 volt service should be placed at convenient locations every 12 feet (3.7 meters) and in every booth. Ground fault interrupters should be provided throughout the shop. The use of magnetic starters on all equipment is an additional safety feature which gives a machine motor overload protection as well as low-voltage, and no-voltage protection. After a power failure has been corrected, the machine will not start (even if it was running when the failure occurred) until the operator presses the start button.

A disconnect switch that can be locked out, must be provided to cut off all power equipment, including power sources in the shop. Panic switches should be strategically located around the entire shop or laboratory and their locations known by all welding personnel. They should be wired to cut off power to every machine. Fused disconnect switches should be provided for each power source and there should be no exposed wiring.

C1.10 Ventilation.

Individual, movable exhaust hoods are highly desirable at the work site. Welding station exhaust should be separate from other laboratory exhaust systems. The minimum required air velocity at the zone of welding is 100 feet per minute (.5 meters per second) when the hood is at its farthest position from the joint being welded. The hood size and height could be reduced to lower the required capacity of the exhaust system. The use of a qualified heating, ventilation, and air conditioning (HVAC) contractor is strongly recommended, rather than having a inexperienced sheet metal firm perform the construction. Fire resistant, safety yellow, strip curtains could be lowered to form a booth when greater exhaust efficiency is desired at the demonstration area.

For the single welding booth, it is practical to design a hood exhaust system. When there are a large number of booths being used, it is more practical to provide exhaust at the arc than for the entire room. However, the loss of heat during the cold months is a serious objection to the room ventilation method unless a heated air intake system is used. To avoid this heat loss, electronic precipitators, which clean the exhausted air and reintroduce it back into the laboratory to save heat and air conditioned air, should be used. These units need careful placement as welding schools create more smoke than most industry applications due to large numbers of units in a contained work area.

C1.11 Heating.

Heating and cooling capacity must take into consideration the provision for a supply of fresh, clean incoming air. The laboratory heating system should automatically maintain a temperature of 68° Fahrenheit (20° Celsius) measured 60 inches (1.5 meters) above the floor. The classroom and the office should be kept at 70° Fahrenheit (21° Celsius) measured 30 inches (762 millimeters) above the floor. A system of even heat distribution should be kept within 5% of these temperatures for health reasons and for stability of equipment and stored materials.

C1.12 Water.

Hot and cold running water, with suitable drinking fountains in the laboratory, and convenient sanitary restrooms are necessities. Washing facilities of either the half round or trough type sink are essential and, as a rule of thumb, should be adequate to accommodate one quarter of the welding personnel simultaneously. Location of the washing facilities should be as near the door as feasible. Drinking fountains are highly desirable and should be available within the welding facility. A safety shower and eye wash station should also be located within each laboratory area. Proper drainage must be considered during installation.

C1.13 Safety.

Information regarding safety can be found in ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*; ANSI/AWS F2.2, *Lens Shade Selector*; ANSI/AWS F3.1, *Guide for Welding Fume Control*; AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting of Containers That Have Held Hazardous Substances*, as well as all other applicable local, state and federal regulations. Equipment must conform to the OSHA requirements for "lockout and tagout."

All safety features of the primary structure(s) and its support system(s) must conform to any local, state or federal governing codes. The school must be able to pass an inspection of the local and state Fire Marshal and possess a certificate of conformance from the regional OSHA engineer.

C2.0 Equipment and Supplies.

C2.1 Instructional Equipment.

C2.2 Welding/Cutting.

The total number of welding work stations should exceed the number of welding personnel enrolled. Ideally, there should be 25 percent more welding stations than there are welding personnel, in order to provide for expansion of enrollment. Most of the stations should be equipped with multi-process power sources. Since SMAW is the most popular welding process, it and at least one other joining process should be linked together.

C2.2.1 Arc Welding.

At least thirteen (13) combination constant current/constant voltage power sources for SMAW, GMAW, GTAW, and FCAW, and thirteen (13) constant current AC/DC power sources with high frequency for GTAW should be provided for every 20 welding personnel. Local industry and adult extension classes may dictate modifications to this structure.

Power sources for SMAW, and GTAW should have a minimum rated output of 60% duty cycle at 300 amperes. Power sources for GMAW and FCAW should have a minimum rated output of 100% duty cycle at 300 amperes. Power sources must be installed in accordance with the National Electrical Code, and be equipped with work leads, electrode holders, guns and/or torches.

An engine driven welder (1) per school should be adequate with both constant current and constant voltage output. Minimum rated welding output should be 200 amps cc/cv at 60% duty cycle. The fuel supply can be gasoline, diesel or propane.

C2.2.2 Oxyfuel Gas Cutting and Welding.

Five (5) oxyfuel gas cutting/heating/welding torches should be provided for every 20 welding personnel. It is recommended that one (1) oxyfuel gas cutting machine be made available for demonstration and instruction. All oxyfuel gas equipment should be of industrial quality and should be appropriate for the thickness of the material being utilized in the instructional program. A distribution system for piping gases to work stations is recommended, along with one (1) portable cylinder set up per 20 welding personnel. This will facilitate instruction in safely setting up and changing compressed gas cylinders. Flashback arrestors must be provided.

C2.2.3 Plasma Arc Cutting (PAC).

Two (2) plasma arc cutting machines should be provided for every 20 welding personnel. Equipment that utilizes compressed air is recommended for cutting. Plasma arc gouging is also a recommended feature. Optional compressed gases can be available, but are not a mandatory part of the cutting package. The plasma arc power source and torch should be rated to cut a minimum of 1/2 inch (12.7 mm) carbon steel at 10 inches (254 mm) per minute travel speed. The plasma arc power source should should have a minimum rated output of 60% duty cycle at 300 amperes.

C2.2.4 Air Carbon Arc Cutting (CAC–A).

Two (2) cutting/gouging torch should be provided for every twenty (20) welding personnel. CAC–A equipment uses compressed air for either cutting or gouging. The torch and machine should be rated to cut/gouge a minimum of 1 inch (25.4 mm) carbon steel at 10 inches (254 mm) per minute travel speed. The CAC–A power source should have a minimum rated output of 60% duty cycle at 300 amperes.

ANNEX D
Addresses of Major Associations of the Welding Fabricating Industry

American Welding Society (AWS)[1]
550 N.W. LeJeune Rd.
P.O. Box 351040
Miami, FL 33135
(305)-443-9353

Aluminum Association (AA)[1]
900 19th St., N.W.
Suite 300
Washington, DC 20006
(202) 862-5100

American Petroleum Institute (API)
1220 L Street, N.W.
Washington, D.C. 20005
(202) 682-8000

American Association of State Highway Officials (AASHTO)
444 N. Capital St., N.W.
Washington, D.C. 20001
(202) 624-5800

Association of American Railroads (AAR)
50 F Street, N.W.
Washington, D.C. 20001
(202) 635-2100

Abrasive Engineering Society (AES)
1700 Painters Run Road
Pittsburgh, PA 15243
(412) 221-0909

American Gas Association (AGA)
1515 Wilson Blvd.
Arlington, VA 22209
(703) 841-8400

American Institute of Mining, Metallurgical and Petroleum Engineering (AIME)
345 East 47th St.
New York, NY 10017
(212) 705-7695

American Institute of Plant Engineers (AIPE)
3975 Erie Ave.
Cincinnati, OH 45208
(513)561-6000

American Institute of Steel Construction (AISC)
400 N. Michigan Ave.
Chicago, Illinois 60611
(312) 670-2400

Association of Iron and Steel Engineers (AISE)
Three Gateway Center
Suite 2350
Pittsburg, PA 15222
(412) 281-6323

American Iron and Steel Institute (AISI)[1]
1000 16th St., N.W.
Washington, D. C. 20036
(202) 452-7236

American Nuclear Society (ANS)
555 North Kensington Ave.
La Grange Park, IL 60525
(312) 352-6611

American National Standards Institute (ANSI)
1430 Broadway
New York, New York 10018
(212) 642-4900

American Railway Engineering Association (AREA)
50 F Street, N.W.
Washington, D.C. 20001
(202) 639-2190

American Society of Civil Engineers (ASCE)
345 East 47th Street
New York, NY 10017
(212) 705-7496

ASM International (ASM)
Route 87
Metals Park, OH 44073
(216) 338-5151

American Society of Mechanical Engineers (ASME)
345 East 47th Street
New York, New York 10017
(212) 705-7722

American Society for Nondestructive Testing (ASNT)
4153 Arlingate Plaza
Columbus, Ohio 43228
(614) 274-6003

American Society for Quality Control (ASQC)
310 W. Wisconsin Ave.
Milwaukee, WI 53203
(414) 272-8575

Major Association Addresses continued:

American Society of Safety Engineers (ASSE)
1800 East Oakton
Des Plaines, IL 60018-2187
(312) 692-4121

American Society for Testing Materials (ASTM)[1]
1916 Race Street
Philadelphia, Pennsylvania 19103
(215) 299-5400

American Welding Institute (AWI)
Knoxville Lab
Route 4, Box 90
Louisville, TN 37777
(615) 970-2150

American Water Works Association (AWWA)
6666 W. Quincy Avenue
Denver, Colorado 80235
(303) 794-7711

American Bureau of Shipping (ABS)
45 Eisenhower Drive
Paramus, New Jersey 07652
(201) 368-9100

Canadian Standards Association (CSA)
178 Rexdale Boulevard
Rexdale, Ontario
Canada M9W 1R3
(416) 744-4000

Canadian Welding Bureau (CWB)
254 Merton Street
Toronto, Ontario M4S 1A9
Canada
(416) 487-5415

Canadian Welding Development Institute (CWDI)
391 Burnhamthorpe Rd.
East Oakville, Ontario L6J 4Z2
Canada
(416) 845-9881

Copper Development Association1
2 Greenwich Office Park
Box 1840
Greenwich, CT 06836-1840
(203) 625-8210

Compressed Gas Association (CGA)
1235 Jeff Davis Highway
Arlington, Virginia 22202
(703) 979-0900

Cryogenic Society of America (CSA)
1033 South Blvd.
Oak Park, IL 60302
(312) 383-7053

Edison Welding Institute (EWI)
1100 Kinnear Rd.
Columbus, OH 43212
(614) 486-9400

Fabricators & Manufacturers' Association International (FMA)
7811 N. Alpine Rd.
Rockford, IL 61111
(815) 654-1902

Grinding Wheel Institute (GWI)
712 Lakewood Center North
14600 Detroit Ave
Cleveland, OH 44107
216-226-7700

Industrial Accident Prevention Association (IAPA)
100 Front Street West
Royal York Hotel Arcade
Toronto, Ontario M5J1R3
Canada
(416) 366-3711

Industrial Safety Equipment Association (ISE)
1901 N. Moore St.
Arlington, VA 22209
(703) 525-1695

International Institute Of Welding (IIW)
550 N. W. LeJeune Road
P.O. Box 351040
Miami, FL 33126
(305) 443-9353

International Organization for Standardization (ISO)
(See American National Standards Institute)

International Oxygen Manufacturers' Association (IOMA)
P.O. Box 16248
Cleveland, OH 44116
(216) 228-2166

Material Handling Institute (MHI)
8720 Red Oak Blvd.
Suite 201
Charlotte, NC 28210
(704) 522-8644

Major Association Addresses continued:

National Association of Corrosion Engineers (NACE)
Box 218340
Houston, TX 77218
(713) 492-0535

National Board of Boiler and Pressure Vessel Inspectors (NBBPVI)
1055 Crupper Avenue
Columbus, Ohio 43229
(614) 888-8320

National Electrical Manufacturers' Association (NEMA)
2101 L. St., N.W.
Washington, DC 20037
(202) 457-8400

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, Massachusetts 02269
(617) 770-3000

Naval Publication and Forms Center[2]
5801 Taber Avenue
Philadelphia, Pennsylvania 19120
(215) 697-2000

Steel Tank Institute (STI)
P.O. Box 4020
North Brook, IL 60065
(312) 498-1980

Superintendent of Documents [3]
U. S. Government Printing Office
Washington, DC 20402
(202) 783-3238

Titanium Development Association
P.O. Box 2307
Dayton, OH 45401
(513) 223-8432

Ultrasonic Industry Association (UIA)
P.O. Box 5126
Old Bridge, NJ 08857
(201) 521-4441

Underwriters Laboratories, Inc. (UL)
333 Pfingsten Road
Northbrook, Illinois 60062
(312) 272-8800

Uniform Boiler and Pressure Vessel Laws Society (UBPVLS)
2838 Long Beach Road
Oceanside, New York 11572
(516) 536-5485

Welding Research Council (WRC)
345 East 47th St.
Suite 1301
New York, NY 10017
(212) 705-7956

Welded Steel Tube Institute (WSTI)
522 Westgate Tower
Cleveland, OH 44116
(216) 333-4550

Note: For a detailed explanation of the agencies listed herein refer to AWS Welding Handbook, Vol 1, Chapter 13, "Codes and Standards"

1 Number Assigner for "UNS"
2 Military Specifications
3 Federal Specifications

ANNEX E
Recommendations for Personal and Shop Materials, Equipment and Tools

INDIVIDUAL EQUIPMENT and TOOLS

Personal protective clothing and equipment

- suitable work clothing (to match service conditions for welding process employed, must be fire resistant)
- leather jacket, cape, sleeves or apron (optional)
- leather gloves
- hightop leather safety shoes or boots (steel toed are recommended)
- welders hat or skullcap
- spectacles w/side shields (clear lens)
- burning goggles or face shield (OFC & PAC)
  - 2 ea. #5 filter plate/lens
  - 2 ea. #7 filter plate/lens
  - 4 ea. clear cover plate/lens
- noise protection (ear plugs)
- welding helmet
- welding lenses (to match helmet design)
  - 2 ea. #10 shaded filter plate/lens
  - 2 ea. #12 shaded filter plate/lens
  - 4 ea. clear cover plate/lens

Personal tools

- carbon steel wire brush
- stainless steel wire brush
- 16 ounce ball peen hammer
- soap stone
- center punch
- metal scribe
- measuring devices
  - steel tape measure (minimum 10')
  - combination square set
  - english/metric steel bench rule (min. 12")
  - framing square
  - bevel gauge
  - pipe layout tools
  - steel dividers (radius maker, min. 6")
  - handheld calculator
- chipping hammer
- 10" mill file (half round–bastard cut)
- cold chisel (size optional)
- pliers, wrenches and clamps
  - 12" adjustable wrench
  - tank wrench (optional)
  - 10" groove or slip joint pliers
  - 6" side or diagonal cutting pliers
  - 6" needle nosed pliers
  - 10" vise grips; 10" vise grip clamp
  - allen or hex wrench set (to 3/8")
- screwdrivers
  - flat head
  - phillips head
- oxyfuel friction lighter, flints and tip cleaners
- visual examination toolkit
  - flashlight
  - fillet gauge
  - weld gauge
  - undercut gauge
  - magnifier
  - micrometer
  - dial caliper
  - rule

EQUIPMENT and TOOLS

first aid kit

eye wash station

chemical shower

fire extinguisher

bench vise (medium duty)

4 ea. 8" C–clamps
grinders (2ea.) and accessories
- 4", 41/2" or 5" right angle grinder
- 7"/9" right angle grinder
- 25 ea. grinding wheels (general purpose and aluminum)

needle gun or scaler

1 set adjustable wrenches

1 set allen or hex wrenches (to 3/8")

1 set screwdrivers (flat and phillips head)

1 set vise grips

steel topped layout or work bench (4'x8'x31")

oxyfuel burning table with dross pan and replaceable slats (4'x8'x31")

work area protective screens (as required)

ventilation equipment

electrode oven

visual examination toolkit
- flashlight
- fillet gauge
- weld gauge
- undercut gauge
- magnifier
- micrometer
- dial caliper
- rule

Destructive and nondestructive testing equipment
- guided bend test jig or machine
- penetrant test kit
- magnetic particle testing equipment

compressed air supply and accessories
(minimum delivery 80 psi @ 8 cfm per station)
- 1/2" compressed air hose (length optional)
- compressed air regulator (to match system output)
- M/F quick couples and adaptors (to accommodate pneumatic tools or air
- carbon arc cutting torch
- hose repair kit with crimping tool

arc welding/cutting power source(s) and accessories

Note: *Selection of a single multipurpose power source able to meet all welding needs with respect to process, method of metal transfer and materials is limited. Given this limitation, a combination of power sources may be necessary to meet Level III – Expert Welder training needs. All shielding gases should be welding grade.*

shielded metal arc
(minimum rating – AC/DC – constant current (CC) 300 amp @ 60%)
- 25' 2/0 electrode cable
- 25' 2/0 workpiece cable
- 2/0 cable lugs and connects (to suit)
- workpiece clamp (amp capacity to suit)
- electrode holder (to 3/16" capacity)

gas tungsten arc
(minimum rating AC/DC – constant current (CC) 300 amp @ 60%)
- high frequency control
- gas purge control (optional)
- remote control (optional)
- water circulation and control (optional)

torch (25', amps and cooling to suit)
accessory kit (to suit)
workpiece clamp (amp capacity to suit)
part repair/replacement kit (to suit)
flow meter(s) (argon, helium service)

air carbon arc
(minimum rating – AC/DC – constant current (CC) 300 amp @ 60%)
25' 2/0 electrode cable
25' 2/0 workpiece cable
2/0 cable lugs and connects (to suit)
workpiece clamp (amp capacity to suit)
torch (light – medium duty)

gas metal arc (spray and short circuit)
(minimum rating – DC – constant voltage (CV or CP with pulsed arc controls) 300 amp @ 100%)
25' 2/0 electrode cable
25' 2/0 workpiece cable
2/0 cable lugs and connects (to suit)
workpiece clamp (amp capacity to suit)
wire feeder (to suit power supply and wire diameter)
gun (15', amp and cooling to suit)
consumable parts kit (to suit)
parts repair/replacement kit (to suit)
flow meter(s) (CO_2 or mixtures Ar/O_2, Ar/CO_2)

flux cored arc
(minimum rating – DC – constant voltage (CV or CP) 300 amp @ 100%)
25' 2/0 electrode cable
25' 2/0 workpiece cable
2/0 cable lugs and connects (to suit)
workpiece clamp (amp capacity to suit)
wire feeder (to suit power supply and wire diameter)
self-shielded gun (15', amp and cooling to suit)
gas shielded gun (15', amp and cooling to suit)
consumable parts kit (to suit)
parts repair/replacement kit (to suit)
flow meter(s) (CO_2 or mixtures Ar/CO_2)

plasma arc
(1/2" cutting capacity)
cutting torch (25', low volt, air primary and secondary)
machine cutting torch (25', low volt, air primary and secondary)
workpiece clamp (amp capacity to suit)
consumable parts kit (to suit)
part repair/replacement kit (to suit)
air regulator (to suit)

oxyfuel gas cutting
manual oxyfuel gas cutting torch and accessories
cutting torch (manual or combination assembly)
oxygen regulator (to suit system)
fuel gas regulator (to suit system)
25' oxyfuel gas hose
4 ea. (per unit) 00 – 4/0 cutting tips
4 ea. (per unit) 2/0 gouging tips
1 ea. (per unit) heating tip (optional)
consumable parts kit
part repair/replacement kit (to suit)
cylinder cart
cylinder wrench
friction lighter, flints and tip cleaner

machine oxyfuel gas
cutting machine torch assembly (to suit)
drive unit (track burner)
pipe beveling drive unit (manual or machine operated)
rails or track
oxygen regulator (to suit supply)
fuel gas regulator (to suit supply)
25' oxyfuel gas hose
2 ea. (per unit) 00 – 4/0 cutting tips
consumable parts kit
part repair/replacement kit (to suit)
cylinder wrench
friction lighter, flints and tip cleaner

oxyfuel gas supply
oxygen supply (capacity to suit)
fuel gas supply (capacity and type to suit)

FABRICATION EQUIPMENT (optional)

shear 1/4" capacity
press brake 1/2" x 8' capacity
ironworker
pipe/tubing bender
pedestal grinder
band saw
drill press
crane (A–frame)
plate/sheet roller 1/2 x 8' capacity
welding positioner
cage, cylinder storage
tool room, secure storage

MATERIALS

multi-view, multiple page drawings
used radiographs (for interpretation)

base metals
useable pieces for all types material (thickness optional)
sheet, nickel or nickel alloys (alloy type optional within alloy group, thickness optional)
sheet, copper alloys (alloy type optional within alloy group, thickness optional)
sheet, magnesium or magnesium alloys (alloy type optional within alloy group, thickness optional, optional if titanium used)
sheet, titanium or titanium alloys (alloy type optional within alloy group, thickness optional, optional if magnesium used)
12" Ø, Schedule 80 carbon steel pipe (optional schedule and diameter ≥ 6" Ø if requirements for 6GR testing are met)
2-1/2" – 6" Ø, Schedule 40 carbon steel pipe (optional diameter size, except use 2-1/2" Ø for GTAW if used)
2-1/2" – 6" Ø, Schedule 10S stainless steel pipe (optional diameter size, except use 2-1/2" Ø for GTAW if used)
2-1/2" – 6" Ø, Schedule 10S carbon steel pipe (optional diameter size, except use 2-1/2" Ø for GTAW)
2-1/2" – 6" Ø, Schedule 40 aluminum pipe (optional diameter size, except use 2-1/2" Ø for GTAW)
2-1/2" Ø, 0.06" – 0.14" thickness carbon steel round tubing (wall thickness optional, pipe may be substituted)
2-1/2" Ø, 0.06" – 0.14" thickness stainless steel round tubing (wall thickness optional, pipe may be substituted)
2-1/2" Ø, 0.06" – 0.14" thickness aluminum round tubing (wall thickness optional, pipe may be substituted)

SMAW filler metal
100# 3/32" E7018
100# 1/8" E7018
100# 5/32" E7018
100# 1/8" E6010
100# 5/32" E6010
100# 1/8" E6011
100# 5/32" E6011
100# 3/32" E3XX–15 or –16 (optional type)
100# 1/8" E3XX–15 or –16 (optional type)
100# 5/32" E3XX–15 or –16 (optional type)

GMAW filler metal and shielding gas
2 spools (per unit) .035 E70S–X
2 spools (per unit) .045 E70S–X
2 spools (per unit) 3/64" E4043
2 spools (per unit) 1/16" E4043
2 spools (per unit) 3/64" E5XXX
2 spools (per unit) 1/16" E5XXX
100% argon (capacity to suit)
100% helium (capacity to suit)
75% argon + 25% CO_2 (capacity to suit) or CO_2 (capacity to suit)
Anti-spatter spray or gel

FCAW filler metal and shielding gas
2 spools (per unit) .045 E71T–1
2 spools (per unit) 1/16" E71T–1
2 spools (per unit) .045 E71 T–11
2 spools (per unit) 1/16" E71 T–11
CO_2 (capacity to suit) or 75% argon + 25% CO_2 (capacity to suit)

GTAW electrodes, filler metal, and shielding gas
- 4 pkg. at 10 pc. ea. 1/16" EWTh–1 or 2
- 4 pkg. at 10 pc. ea. 3/32" EWTh–1 or 2
- 4 pkg. at 10 pc. ea. 1/8" EWTh–1 or 2
- 4 pkg. at 10 pc. ea. 1/16" EWCe–2
- 4 pkg. at 10 pc. ea. 3/32" EWCe–2
- 4 pkg. at 10 pc. ea. 1/8" EWCe–2
- 4 pkg. at 10 pc. ea. 1/16" EWP
- 4 pkg. at 10 pc. ea. 3/32" EWP
- 4 pkg. at 10 pc. ea. 1/8" EWP
- 4 pkg. at 10 pc. ea. 1/16" EWZr
- 4 pkg. at 10 pc. ea. 3/32" EWZr
- 4 pkg. at 10 pc. ea. 1/8" EWZr
- 40# 1/16" ER70S–2 (carbon steel rod)
- 40# 3/32" ER70S–2 (carbon steel rod)
- 40# 1/8" ER70S–2 (carbon steel rod)
- 40# 1/16" ER4043 (aluminum rod)
- 40# 3/32" ER4043 (aluminum rod)
- 40# 1/8" ER4043 (aluminum rod)
- 40# 1/16" ER5XXX (aluminum rod)
- 40# 3/32" ER5XXX (aluminum rod)
- 40# 1/8" ER5XXX (aluminum rod)
- 40# 1/16" ER3XX (stainless rod)
- 40# 3/32" ER3XX (stainless rod)
- 40# 1/8" ER3XX (stainless rod)
- 40# 1/16" ERNi (or suitable nickel alloy rod)
- 40# 3/32" ERNi (or suitable nickel alloy rod)
- 40# 1/8" ERNi (or suitable nickel alloy rod)
- 40# 1/16" ERCu (or suitable copper alloy rod)
- 40# 3/32" ERCu (or suitable copper alloy rod)
- 40# 1/8" ERCu (or suitable copper alloy rod)
- 40# 1/16" ERAZXX (or suitable magnesium alloy rod)
- 40# 3/32" ERAZXX (or suitable magnesium alloy rod)
- 40# 1/8" ERAZXX (or suitable magnesium alloy rod)
- 40# 1/16" ERTi-X (or suitable titanium alloy rod)
- 40# 3/32" ERTi-X (or suitable titanium alloy rod)
- 40# 1/8" ERTi-X (or suitable titanium alloy rod)
- 100% argon (capacity to suit)
- 100% helium (capacity to suit)

Note: Nickel, copper, magnesium or titanium and alloys choice of diameter and filler metal type optional within base metal groupings.

CAC–A electrodes
- 4 boxes 1/8" DC copper clad, pointed
- 4 boxes 5/32" DC copper clad, pointed
- 4 boxes 1/4" DC copper clad, pointed
- 4 boxes 3/8" DC copper clad, flat

AWS LEVEL III - EXPERT WELDER
TRAINING ACHIEVEMENT RECORD

Name: _____ Social Security #: _____ Date Entered Training: _____

Training Facility: _____ Date of Completion: _____

Address: _____

_____

_____

Telephone #: _____

Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.1 COURSE A: WELDING SAFETY and HEALTH **Unit :** (no units this course) **Learning Objectives**					
(1) Follow safe practices.					
(2) Recognize the effects of welding on health.					
3.2.1.2 COURSE B: SUPERVISION and MANAGEMENT **Unit :** (no units this course) **Learning Objectives**					
(1) Supervise other personnel during fabrication and welding operations.					
(2) Administer hands-on training.					
(3) Participate in the selection and specification of equipment purchases.					
(4) Estimate welding and material costs and quantities.					

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Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.3 COURSE C: DOCUMENTS GOVERNING WELDING AND WELDING INSPECTION					
Unit1: WELDING CODES and OTHER STANDARDS					
Learning Objectives					
(1) Locate essential welding and inspection information from Welding Procedure Specifications (WPS).					
(2) Locate essential welding and inspection information from AWS D1.1, *Structural Welding Code – Steel.*					
(3) Locate essential welding and inspection information from API Standard 1104, *Standard for Welding Pipelines and Related Facilities.*					
(4) Locate essential welding and inspection information from ASME, *Boiler and Pressure Vessel Code – Section IX.*					
Unit 2: WELDING INSPECTION					
Learning Objectives					
(1) Interpret destructive and nondestructive test results.					
(2) Prepare inspection reports.					
(3) Perform visual examination.					
(4) Perform bend testing.					
(5) Perform penetrant testing.					
(6) Perform magnetic particle testing.					

Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.4 COURSE D: WELDED METAL FABRICATION					
Unit : (no units this course)					
Learning Objectives					
(1) Troubleshoot fabrication setups and processes.					
(2) Interpret welding, nondestructive examination and piping symbols.					
(3) Layout parts using advanced measurement practices.					
(4) Fabricate weldments from complex drawings.					
(5) Fabricate jigs and fixtures.					
3.2.1.5 COURSE E: WELDING METALLURGY					
Unit: (no units this course)					
Learning Objectives					
(1) Apply principles of welding metallurgy to welding, fabrication and inspection.					
(2) Apply principles of metal properties to welding, fabrication and inspection.					
(3) Apply principles related to residual stress and distortion to welding, fabrication and inspection.					
(4) Apply principles related to alloy weldability to welding, fabrication and inspection.					

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Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.6 COURSE F: ARC WELDING PRINCIPLES and PRACTICES					
Unit 1: WELDING THEORY					
Learning Objectives					
(1) Apply principles of joint design and preparation to welding, fabrication and inspection.					
(2) Apply principles of material selection to welding, fabrication and inspection.					
(3) Apply principles of welding applications to welding, fabrication and inspection.					
(4) Apply principles of weld quality and repairs to welding, fabrication and inspection.					
Unit 2: SHIELDED METAL ARC WELDING (SMAW)					
Learning Objectives					
(1) Perform safety inspections of equipment and accessories.					
(2) Make minor external repairs to equipment and accessories.					
(3) Set up components and accessories of a complete shielded metal arc welding system.					
(4) Set up for shielded metal arc welding operations.					
(5) Operate shielded metal arc welding equipment.					
(6) Execute corrective actions to repair surface flaws on welds and base metals.					
(7) Perform a 6GR unlimited thickness range performance qualification test on carbon steel pipe.					

Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
(8) Perform a 6G limited thickness range performance qualification tests on carbon steel or stainless steel pipe using stainless steel electrodes.					
Unit 3: GAS METAL ARC WELDING (GMAW, GMAW–S)					
Learning Objectives					
(1) Perform safety inspections of equipment and accessories.					
(2) Make minor external repairs to equipment and accessories.					
(3) Set up components and accessories of a complete gas metal arc welding system.					
(4) Set up for gas metal arc welding operations.					
(5) Operate gas metal arc welding equipment.					
(6) Execute corrective actions to repair surface flaws on welds and base metals.					
Short circuit transfer					
(7) Perform a 6G limited thickness range performance qualification test on carbon steel pipe.					
Pulsed spray transfer					
(8) Perform a 6G limited thickness range performance qualification test on aluminum pipe.					
Unit 4: FLUX CORED ARC WELDING (FCAW–S, FCAW–G)					
Learning Objectives					
(1) Perform safety inspections of equipment and accessories.					

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Course, Units and Learning Objectives	Performance PASS	Performance FAIL	Date Completed	Instructor's Initials	Trainee's Initials
(2) Make minor external repairs to equipment and accessories.					
(3) Set up components and accessories of a complete flux cored arc welding system.					
(4) Set up for flux cored arc welding operations.					
(5) Operate flux cored arc welding equipment.					
(6) Execute corrective actions to repair surface flaws on welds and base metals.					
Self-Shielded (7) Perform a 6G unlimited thickness range performance qualification test on carbon steel pipe.					
Gas-Shielded (8) Perform a 6G unlimited thickness range performance qualification test on carbon steel pipe.					
Unit 5: GAS TUNGSTEN ARC WELDING (GTAW)					
Learning Objectives					
(1) Perform safety inspections of equipment and accessories.					
(2) Make minor external repairs to equipment and accessories.					
(3) Set up components and accessories of a complete gas tungsten arc welding system.					
(4) Set up for gas tungsten arc welding operations.					
(5) Operate gas tungsten arc welding equipment.					

Course, Units and Learning Objectives	Performance PASS	FAIL	Date Completed	Instructor's Initials	Trainee's Initials
(6) Execute corrective actions to repair surface flaws on welds and base metals.					
(7) Make 2F and 1G fillet and groove welds, on nickel alloys.					
(8) Make 2F and 1G fillet and groove welds, on copper alloys.					
(9) Make 2F and 1G fillet and groove welds, on magnesium and/or titanium alloys.					
(10) Perform a 6G limited thickness range performance qualification test on carbon steel round tubing or pipe.					
(11) Perform two 6G limited thickness range performance qualification tests on carbon steel or 300 series stainless steel round tubing or pipe.					
(12) Perform a 6G limited thickness range performance qualification test on aluminum round tubing or pipe.					

WRITTEN EXAMINATION AND PERFORMANCE QUALIFICATION TESTING EVALUATION

	Test Attempts (per AWS QC12)	Score or Pass/Fail/ Substitution*	Date Completed	Instructor's Initials	Trainee's Initials
Safety Pretest (100% required)					
PERFORMANCE QUALIFICATIONS*					
SMAW — 6GR — Carbon Steel Pipe					
SMAW — 6G — Stainless Steel (Carbon Steel or Stainless Steel Pipe)					

	Test Attempts (per AWS QC12)	Score or Pass/Fail/ Substitution*	Date Completed	Instructor's Initials	Trainee's Initials
GMAW-S — 6G—Carbon Steel Pipe					
GMAW-P—Aluminum Pipe					
FCAW-S — 6G — Carbon Steel Pipe					
FCAW-G — 6G — Carbon Steel Pipe					
GTAW — 6G — Carbon Steel Round Tubing or Pipe					
GTAW — 6G — Stainless Steel Carbon Steel or Stainless Steel Round Tubing or Pipe (with consumable insert)					
GTAW — 6G — Stainless Steel Carbon Steel or Stainless Steel Round Tubing or Pipe (without consumable insert)					
*Substitution see optional QC7 section					
WRITTEN EXAMINATION*					
Safety Post-test (from Part A, 90% required)					
Part A - Welding Fundamentals and Safety					
Part B - Practical Welding Specification Interpretation (visual examination of welds to a standard)					
Part C - Code Book Interpretation: AWS D1.1 (if code of choice)					
API 1104 (if code of choice)					
ASME, Section IX (if code of choice)					
*Substitution see optional QC1 section					

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AWS QC 12 - Optional AWS QC7 Welder Performance Qualification Tests

(These welder performance qualification tests superceded the performance qualification requirements of AWS QC12 as detailed in AWS EG4.0, Section 4 and were administered at an AWS QC4, Accredited Test Facility, within the guidelines of the AWS QC7, AWS Certified Welder Program and AWS QC7 Supplement G. Visual Examination, Bend Testing or Radiography in accordance with AWS B2.1, Standard for Welding Procedure and Performance Qualification. For other standards or employer's qualified welding procedures, Visual Examination, Bent Testing or Radiography in accordance with the fabricating document.)

	Governing Standard	Attempts per QC7, Sec. 7	Accept or or Reject	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.6 COURSE F: ARC WELDING PRINCIPLES and PRACTICES[1]						
Unit 2: SHIELDED METAL ARC WELDING (SMAW)						
(7) SMAW — 6GR — Carbon Steel Pipe						
(8) SMAW — 6G — Stainless Steel (Carbon Steel or Stainless Steel Pipe w/ stainless filler)						
Unit 3: GAS METAL ARC WELDING (GMAW-S, GMAW-P)						
(7) GMAW-S — 6G — Carbon Steel Pipe						
(8) GMAW-P — 6G — Aluminum Pipe						
Unit 4: FLUX CORED ARC WELDING (FCAW-S, FCAW-G)						
(7) FCAW-S — 6G — Carbon Steel Pipe						
(8) FCAW-G — 6G — Aluminum Pipe						

Notes: [1] Numbers in ( ) indicate the actual learning objective number of the performance qualification test from AWS EG4.0 that was substituted by the AWS QC12 optional QC7 performance qualification test.

	Governing Standard	Attempts per QC7, Sec. 7	Accept or or Reject	Date Completed	Instructor's Initials	Trainee's Initials
3.2.1.6 COURSE F: ARC WELDING PRINCIPLES and PRACTICES[1]						
Unit 5: GAS TUNGSTEN ARC WELDING (GTAW)						
(10) GTAW — 6GR — Carbon Steel Round Tubing or Pipe	_____	_____	_____	_____	_____	_____
(11) GTAW — 6G — Stainless Steel (with consumable insert) (Carbon Steel or Stainless Steel Round Tubing Pipe w/ stainless filler)	_____	_____	_____	_____	_____	_____
(11) GTAW — 6G — Stainless Steel (without consumable insert) (Carbon Steel or Stainless Steel Round Tubing or Pipe w/ stainless filler)	_____	_____	_____	_____	_____	_____
(12) GTAW — 6G — Aluminum Round Tubing or Pipe	_____	_____	_____	_____	_____	_____

Notes: [1] Numbers in ( ) indicate the actual learning objective number of the performance qualification test from AWS EG4.0 that was substituted by the AWS QC12 optional QC7 performance qualification test

AWS QC12 - Optional AWS QC1 Written Examination
(This written examination superceded the written examination requirements of AWS QC12 as detailed in AWS EG4.0, Section 5 and was administered at an AWS approved exam site using an AWS Test Supervisor in accordance with the AWS QC1, *Standard for AWS Certification of Welding Inspectors* for administration of the AWS QC1, Certified Welding Inspector Examination.)

	Expiration Date of QC1 Certification	CWI# or CAWI#	Score	Date Completed	Instructor's Initials	Trainee's Initials
Supplemental Safety Examination (90% min. passing score required)	_____	_____	_____	_____	_____	_____
Part A - Welding Fundamentals and Safety	_____	_____	_____	_____	_____	_____
Part B - Practical Welding Specification Interpretation	_____	_____	_____	_____	_____	_____
Part C - Code Book Interpretation	_____	_____	_____	_____	_____	_____

AWS QC12 - Work Experience

In accordance with the requirements of AWS QC12 Work Experience is mandatory. Documentation of work experience shall meet the requirements outlined in AWS EG4.0 as follows:

1.3.8.1 Trainees desiring AWS Level III – Expert Welder Certification through training, testing and examination under the requirements of AWS QC12 shall meet the requirements of **1.3.7**, **1.3.8** and document two years of multiple welding process work experience (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that has a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

1.3.8.2 Trainees desiring AWS Level III – Expert Welder Certification through testing and examination under the requirements of AWS QC12 shall meet the requirements of **1.3.7**, **1.3.8** and document seven years welding work experience. Said work experience shall consist of three years in a single process and 4 years using multiple processes, (with a minimum of 6 months fabrication experience that includes drawing interpretation, layout and fitup duties) that have a direct relationship to weldments fabricated to a standard or employer's qualified welding procedure.

1.3.8.3 At the discretion of a Participating Organization, credit for completion of individual training requirements and work experience may be simultaneously granted to an AWS QC12 Level III – Expert Welder applicant provided the work experience or experiential learning meets or exceeds the requirements for either work experience or training.

	Documentation Records on File (Yes or No)	Work Study or Employment	Date Completed	Instructor's Initials	Trainee's Initials
Work Experience (Certification through training, examination and testing. See 1.3.8.1 and 1.3.8.3 above)					
Work Experience (Certification through examination and testing. See 1.3.8.2 above)					

INSTRUCTOR'S COMMENTS:

Welding Instructor _____ Date _____

American Welding Society

Certifies That Level III — Expert Welder

IAM WELDER

has met the requirements for training, examination, performance qualification and work experience in accordance with the requirements of the AWS Specification for Qualification and Certification for Level III — Expert Welders QC12 and the Guide for the Training and Qualification of Welding Personnel Level III — Expert Welder EG4.0

DATE

CERTIFICATION DIRECTOR

CERTIFICATE NUMBER

EDUCATION DIRECTOR

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ANNEX H
Reference Materials

Safety and Health

[1,2,3]ANSI Z49.1, ... *Safety in Welding, Cutting and Allied Processes*
[1,2,3]ANSI/AWS F2.2, ... *Lens Shade Selector Chart*
[3]AWS EWH, ... *Effects of Welding on Health I - IX*
[3]AWS, FGW . . . . . *Fumes and Gases in the Welding Environment*
[3]ANSI/AWS F3.1, ... *Guide for Welding Fume Control*
[*3]ANSI Z535.4, ... *Standard for Product Safety Signs and Labels*
[*3]ANSI Z87.1, ... *Practice for Occupational and Educational Eye and Face Protection*
[*3]ANSI Z88.2, ... *Practices for Respiratory Protection*
[*3]ANSI Z89.1, ... *Protective Headware for Industrial Workers*

Welding Symbols

[1,2,3]AWS A2.1, ... *Welding Symbols Chart*
[1,2,3]ANSI/AWS A2.4, ... *Standard Symbols, for Welding, Brazing and Nondestructive Examination*

Terms and Definitions

[1,2,3]ANSI/AWS A3.0, ... *Standard Welding Terms and Definitions*

Filler Metals and Electrodes

[1,2,3]ANSI/AWS A5.1, ... *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.*
[2,3]ANSI/AWS A5.4, ... *Specification for Corrosion-Resisting Chromium and Chromium Nickel Steel Covered Electrodes*
[3]ANSI/AWS A5.7, ... *Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes*
[1,2,3]ANSI/AWS A5.9, ... *Specification for Bare Stainless Steel Welding Electrodes and Rods*
[1,2,3]ANSI/AWS A5.10, ... *Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods*
[1,2,3]ANSI/AWS A5.12, ... *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*
[3]ANSI/AWS A5.14, ... *Specification for Nickel and Nickel Alloy Welding Electrodes and Rods*
[3]ANSI/AWS A5.16, ... *Specification for Titanium and Titanium Alloy Welding Electrodes and Rods*
[1,2,3]ANSI/AWS A5.18, ... *Specification for Carbon Steel Filler Metals for Gas-Shielded Arc Welding*
[3]ANSI/AWS A5.19, ... *Specification for Magnesium and Magnesium Alloy Welding Electrodes and Rods*
[1,2,3]ANSI/AWS A5.20, ... *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
[3]ANSI/AWS A5.30, ... *Specification for Consumable Inserts*

Shielding Gases

[3]ANSI/AWS C5.10, ... *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting.*

Welding Procedure Specifications and Performance Qualifications

[1]ANSI/AWS B2.1.001, . . .*Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Carbon Steel, (M-1/P-1, Group 1 or 2), 3/16 through 3/4 inch, in the As-Welded Condition, With Backing*

[1,2,3]ANSI/AWS B2.1.008, . .*Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Carbon Steel, (M-1, Group 1), 10 Gage through 18 Gage, in the As-Welded Condition, With or Without Backing*

[1,2,3]ANSI/AWS B2.1.009, . .*Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Austenitic Stainless Steel, (M-8/P8), 10 Gage through 18 Gage, in the As-Welded Condition, With or Without Backing*

[3]ANSI/AWS B2.1.010, . . .*Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P8), 10 Gage through 18 Gage, in the As-Welded Condition, With or Without Backing*

[1]ANSI/AWS B2.1.015, . . .*Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Aluminum, (M-22/P-22), 10 Gage through 18 Gage, in the As-Welded Condition, With or Without Backing*

[2]ANSI/AWS B2.1–1–016, .*Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, E7018, As-Welded or PWHT Condition*

[1,2]ANSI/AWS B2.1.019, . .*Standard Welding Procedure Specification (WPS) for CO_2 Shielded Flux Cored Arc Welding of Carbon Steel, (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1 1/2 inch thick, E70T–1 and E71T–1, As-Welded Condition*

[1,2,3]ANSI/AWS B2.1.020, . .*Standard Welding Procedure Specification (WPS) for 75% Argon 25% CO_2 Shielded Flux Cored Arc Welding of Carbon Steel, (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1 1/2 inch thick, E70T–1 and E71T–1, As-Welded or PWHT Condition*

[2]ANSI/AWS B2.1–1–022, .*Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Carbon Steel, (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1 1/2 inch thick, E6010, (Vertical Uphill) Followed By E7018, As-Welded or PWHT Condition*

[2,3]ANSI/AWS B2.1–1–023, *Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Austenitic Stainless Steel (M-8/P-8/S-8, Group 1), 1/8 through 1-1/2 inch Thick, As-Welded Condition*

[1,2,3]ANSI/AWS B2.1–1–027,*Standard Welding Procedure Specification (WPS) for Self-Shielded Flux Cored Arc Welding of Carbon Steel, (M-1/P-1/S-1, Group 1 or 2), 1/8 through 3/4 inch thick, E71T–11, As-Welded Condition*

[1]AWS–1–GMAW–S, ...*Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Short Circuit Transfer on Carbon Steel (M1/P1, Group 1 or 2), 3/16 through 3/4 inch Thick, in the As- Welded Condition*

[1]AWS–2–GMAW, ...*Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Spray Transfer on Carbon Steel (M1/P1, Group 1 or 2), 3/16 through 3/4 inch Thick, As-Welded Condition*

[1]AWS–5–GTAW, ...*Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Aluminum, (M-23 or P-23), 10 Gage through 18 Gage, As-Welded Condition, With or Without Backing*

[2,3]AWS2–1–SMAW, ... *Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Austenitic Stainless Steel to Carbon Steel (M-1 to M-8 or P-8), 1/8 through 1/2 inch Thick, in the As-Welded Condition*

[2]AWS2–1–GMAW, ... *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Spray Transfer of Aluminum, (M-23/P-23/S-23), 1/8 through 3/4 inch Thick, in the As-Welded Condition*

[2]AWS2–1.1–GMAW, ... *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Spray Transfer of Aluminum, (M-22/P-22/S-22), 1/8 through 3/4 inch Thick, in the As-Welded Condition*

[2,3]AWS2–2–GMAW, ... *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Short Circuit Transfer of Carbon Steel (M-1/P-1/S-1, group 1 or 2), 1/8 inch through 3/8 inch Thick, in the As-Welded Condition*

[2]AWS2–3–GMAW, ... *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Spray Transfer of Carbon Steel (M-1/P-1/S-1, group 1 or 2), 1/8 inch through 1-1/2 inch Thick, in the As-Welded Condition*

[2,3]AWS2–1–GTAW, ... *Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Aluminum, (M-23/P-23/S-23), 10 through 18 Gauge Thick, in the As-Welded Condition*

[2,3]AWS2–1.1–GTAW, ... *Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Aluminum, (M-22/P-22/S-22), 10 through 18 Gauge Thick, in the As-Welded Condition*

[3]AWS3–SMAW–1, ... *Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Carbon Steel Pipe (M-1/P-1/S-1, group 1 or 2), in the 6GR Position*

[3]AWS3–GMAW-P–1, . . . *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Pulsed Spray Transfer of Aluminum, (M-22/P-22/S-22), 1/8 through 3/4 inch Thick, in the As-Welded Condition*

[3]AWS3–GMAW-P–2, . . . *Welding Procedure Specification (WPS) for Gas Metal Arc Welding – Pulsed Spray Transfer of Aluminum, (M-23/P-23/S-23), 1/8 through 3/4 inch Thick, in the As-Welded Condition*

[3]AWS3–GTAW–1 . . . . . *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P8), 10 Gage through 18 Gage, in the As-Welded Condition, With Consumable Insert*

[3]AWS3–GTAW–2 . . . . . *Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Austenitic Stainless Steel, (M-8/P8), 10 Gage through 18 Gage, in the As-Welded Condition, With Consumable Insert*

Documents Governing Welding and Welding Inspection

[1,2,3]ANSI/AWS B2.1, ... *Standard for Welding Procedure and Performance Qualification*

[1,2,3]ANSI/AWS B4.0, ... *Standard Methods for Mechanical Testing of Welds*

[3]ANSI/AWS B 1.10, ... *Guide for the Nondestructive Inspection of Welds*

[1,2,3]ANSI/AWS B 1.11, ... *Guide for the Visual Inspection of Welds*

[3]ANSI/AWS D1.1, ... *Structural Welding Code – Steel*

[1,2,3]AWS WHB–1.8, ... *Welding Handbook Volume One, Eighth Edition, Welding Technology*

[*1]API Standard 1104, ... *Welding of Pipelines and Related Facilities*

[1,2,3]ASME B31.1, ... *Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications*
[3]SWR-1, ... *Structural Weld Replica Kit*
[3]PWR-1, ... *Pipe Weld Replica Kit*
[3]TK, ... *Welding Inspectors Tool Kit*

Welding Metallurgy

[1,2,3]WHB–1.8, ... *Welding Handbook Volume One, Eighth Edition, Welding Technology*
[1,2,3]WHB–2.8, ... *Welding Handbook Volume Two, Eighth Edition, Welding Processes*
[3]WHB–3.8, ... *Welding Handbook Volume Three, Eighth Edition, Materials and Applications – Part 1*

Oxyfuel Gas Cutting Process

[1,2]ANSI/AWS C4.1 – *G*, . . . *Oxygen Cutting Surface Roughness Gauge*
[1,2]ANSI/AWS C4.1–*WC*, . . *Criteria for Describing Oxygen-Cut Surfaces*
[1,2]ANSI/AWS C4.2, ... *Operator's Manual for Oxyfuel Gas Cutting*

Arc Welding and Cutting Processes

[1,2]ANSI/AWS C5.3, ... *Recommended Practices for Air Carbon Arc Gouging and Cutting*
[1,2,3]ANSI/AWS C5.5, ... *Recommended Practices for Gas Tungsten Arc Welding*
[1,2,3]ANSI/AWS C5.6, ... *Recommended Practices for Gas Metal Arc Welding*
[1,2,3]WHB–2.8, ... *Welding Handbook Volume Two, Welding Processes*

Base Metals (materials, applications, identification and selection)

[1,2]WHB– 1.8, ... *Welding Handbook Volume One, Welding Technology*
[3]WHB–3.8, ... *Welding Handbook Volume Three, Eighth Edition, Materials and Applications – Part 1*

Program Implementation and Development

[1,2]AWS EG2.0, ... *Guide for the Training and Qualification of Welding Personnel Entry Level Welder*
[1,2,3]AWS EG3.0, ... *Guide for the Training and Qualification of Welding Personnel Level II – Advanced Welder*
[3]AWS EG4.0, ... *Guide for the Training and Qualification of Welding Personnel Level III – Expert Welder*
[2]AWS QC1, ... *Standard for AWS Certification of Welding Inspectors*
[2]AWS QC4, ... *Standard for Accreditation of Test Facilities for AWS Certified Welder Program*
[2]AWS QC5, ... *Standard for Qualification and Certification of Welding Educators*
[2]AWS QC7, ... *Standard for AWS Certified Welders*
[1,2,3]AWS QC10, ... *Specification for Qualification and Certification for Entry Level Welder*

[2,3]AWS QC11, ...*Specification for Qualification and Certification for Level II – Advanced Welder*

[3]AWS QC12, ...*Specification for Qualification and Certification for Level III – Expert Welder*

AWS–OTA, ...*Occupational Task Analysis, Entry Level Welder*

Notes:

[2,3 or 1,2,3] The specified resource material is part of the resource library provided to Participating Organizations for the AWS QC10 Entry Level Welder Program and/or the upgrade for the AWS QC11 Level II – Advanced Welder Program, and have a direct bearing on the AWS QC12 Level III – Expert Welder Program. These documents are not reissued when an existing participating organization upgrades to the AWS QC11 or AWS QC12 programs.

[1] These documents are included as part of the resource library for the AWS QC10, Entry Level Welder Program. To be eligible for this library a training facility must be registered as an AWS QC10 Participating Organization.

[2] These documents are included as additional resource materials required for the AWS QC11 Level II – Advanced Welder Program. To be eligible for this upgrade to the resource library a training facility must be registered as an AWS QC11 Participating Organization.

[3] These documents are included as additional resource materials required for the AWS QC12 Level III – Expert Welder Program. To be eligible for this upgrade to the resource library a training facility must be registered as an AWS QC12 Participating Organization.

[*3] These documents are required but not included as additional resource materials required for the AWS QC12 Level III – Expert Welder Program. To upgrade these materials for the resource library an AWS QC12 Participating Organization will be required to purchase these items separately from the American Welding Society or the vendor handling the particular reference material.

Related Training Materials (Additional Resources from AWS or other organizations)

Except where noted all publications, software or videotapes are available through the AWS Order Department. Call Monday-Friday, 800-443-9353 x320, 8:00 a.m. - 5:00 p.m. EST

Welding Safety and Health

AWS CES-01 . . . . . .*Welding Health and Safety (workbook)*

AWS FSW, ...*Fire Safety in Welding and Cutting*

AWS OWS, ...*Oxyfuel Gas Welding, Cutting, and Heating Safely*

AWS WSV, ...*Welding Safely-The Way the Pros Do It (videotape)*

AWS WSH . . . . . .*Welding Safety and Health (Home Study course)*

Supervision and Management

AWS T94, ...*Quality Management and Quality System Elements: Guidelines*

AWS 054, ...*A Guide to Designing Welds*

Documents Governing Welding and Welding Inspection

AWS–WIT–T, ...*Welding Inspection Technology*

AWS–WIT–W, ...*Welding Inspection Technology Workbook (questions for WIT-T)*

AWS–WIT–I, ...*Welding Inspection Technology Presentation Package*

AWS CM-94, ...*Certification Manual for Welding Inspectors*

IQCC, ...*Welding Inspection and Quality Control (Home Study Course)*

AWS WI-80 . . . . . *Welding Inspection*
WIT-V, ... *Welding Inspection Videotape*
ETS,or ETS-M, ... *NDT Expert Training System (computerized training program)*
N-1608, ... *Liquid Penetrant Testing*
PGR, ... *Practical Guide to Radiographic Interpretation Acceptance Criteria*
H-MT, ... *Magnetic Particle Testing (videotape)*
H-PT, ... *Liquid Penetrant Testing (videotape)*
H-ET, ... *Eddy Current Testing (videotape)*
C-WRT, ... *Weld Comparison Training Kit (classroom package)*
055 . . . . . *NDE Handbook*
AWS PHB-2, ... *The Everyday Pocket Handbook for Visual Inspection and Weld Discontinuities - Causes and Remedies*
AWS HOT, ... HOT/Hands-on Training Text (use of visual exam tools training)
AWS HST, ... Hands-on, Self Training (same as HOT includes tool kit and guide for NDE of welds)
SEQ-1, ... *Weld Sequencing Samples (for GMAW, FCAW, SMAW)*
SMA-1, ... *SMAW Weld Replica Kit*
WSD-1, ... *Weld Sample Defect Plate*
OFC-1, ... *Oxyfuel Flame Cutting Replica Kit*

Welded Metal Fabrication

AWS–ELW–DR, ... *Entry Level Welder – Workmanship and Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS–L2–DR, ... *Level II – Advanced Welder – Workmanship and Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS–L3–DR, ... *Level III – Expert Welder – Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS–WJT, ... *Resource Guide to ... Joint–Weld Terminology and Standard Welding Symbols Interpretation (AWS home study course or classroom use)*
AWS–WJT-T, ... *Transparencies for Resource Guide to ... Joint–Weld Terminology and Standard Welding Symbols Interpretation (for classroom presentation)*
AWS WSD-H, ... *Welding Structural Design (classroom or self-study package with workbook)*
032 . . . . . *The Pipe Fitter's and Pipe Welder's Handbook*
033, ... *Pipe Trades Pocket Manual*
AWS PHB-3, ... *The Everyday Pocket Handbook on Welded Joint Details for Structural Applications*

Welding Metallurgy

AWS WHB-4, ... *Welding Handbook, 7th Edition, Vol. 4, Metal and Their Weldability*
WM1-4, ... *Welding Metallurgy, 4th Edition, Vol. 1, Fundamentals*
WM2, ... *Welding Metallurgy, 3rd Edition, Vol. 2, Technology*
034, ... *The Metals Black Book (ferrous material selection, identification)*
044, ... *The Metals Red Book (nonferrous material selection, identification)*
AWS CES-008, ... *Basic Steel Metallurgy and Material Specification*
AWS CES-009, ... *Basic Welding Metallurgy of Structural Steels*

AWS CES-012, ... *Mechanical Testing of Welds*
AWS CES-020, ... *Structure and Properties of Metals*
AWS CES-021, ... *Welding Metallurgy of Steels*
AWS CES-022, ... *Welding Metallurgy of Stainless Steels*
AWS CES-023, ... *Welding Metallurgy of Non-Ferrous Metals and Cast Iron*

Oxyfuel Cutting, Arc Cutting and Arc Welding Principles and Practices

AWS–ELW–DR, ... *Entry Level Welder – Workmanship and Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS–L2–DR, ... *Level II – Advanced Welder – Workmanship and Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS–L3–DR, ... *Level III – Expert Welder – Workmanship and Performance Qualification Drawings (full size 11 x 17 drawings)*
AWS FMC, ... *Filler Metal Comparison Charts (for filler metal identification and cross-referencing)*
AWS UGFM, ... *User's Guide To Filler Metals*
047, ... *The Metals Blue Book (welding filler metals)*
AWS PHG-1, ... *The Everday Pocket Handbook for Arc Welding Steel*
AWS C5.2, ... *Recommended Practices for Plasma Arc Cutting*
AWS D10.4, ... *Recommended Practices for Austenitic Chromium-Nickel Stainless Steel Piping and Tubing*
AWS D10.6, ... *Recommended Practices for Gas Tungsten Arc Welding of Titanium Piping and Tubing*
AWS D10.7, ... *Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe*
AWS D10.10, ... *Recommended Practices for Local Heating of Welds in Piping and Tubing*
AWS D10.11, ... *Recommended Practices for Root Pass Welding of Pipe Without Backing*
T-WT, ... *How to Weld Titanium (videotape)*
AA–2, ... *Aluminum Welder's Training Manual and Exercises*
AWS CP1194, ... *Maintenance and Repair Welding in Power Plants V*